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Forthcoming Events.

OCTOBER 8-23.
Textile Machinery and Fabrics Exhibition, at Leicester.

OCTOBER 15.
Institute of Metals (Swansea Local Section):—Meeting at Swansea. Chairman's address, by Capt. L. Taverner, A.R.S.M., D.I.C.

OCTOBER 16.
Swansea Technical College Metallurgical Society:—General meeting at Swansea. Presidential address and Paper by D. G. Evans.

OCTOBER 19.
Institute of Transport:—Meeting in London. "Commercial Flying," Paper by Capt. F. L. Barnard.

OCTOBER 21-30.
International Motor Exhibition at the Olympia, London, W.

Institute of British Foundrymen.

OCTOBER 15.
Sheffield and District Section:—Ordinary meeting at Sheffield. Presidential address, "Education in the Foundry," Paper by G. Edginton.

OCTOBER 22.
Sheffield and District Section:—Sorby Lecture at Sheffield. "Methods of Graving Large Metal Crystals," by Professor H. C. Carpenter, F.R.S.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Secretary: F. J. Griffiths, 20, Fisher Street, Swansea.

Foundry Trades Equipment & Supplies Association.
Secretary: K. S. Bridges, Avenue Chambers, Southampton Row, London, W.C.1.

The Ford Ideal

Mr. Ford's new book* "To-day and To-morrow" is of outstanding interest to foundrymen, as it is abundantly clear that the author is a foundryman of a very high order. By this we do not mean he is a craftsman, but a man who insists that the making of castings is a mechanical job capable of being treated as a machine shop engaged on repetition work. He has every right to call himself a foundryman, as he has no less than thirty-four cupolas in regular operation. One of Mr. Ford's tenets is that "a generation ago there were a thousand men to every opportunity, whilst to-day there are a thousand opportunities for every man. The Press provides the public with early information of new developments throughout the world, such as the creation of new industries, whilst transport is available to reach rapidly any new centre showing promise. Examined from an old-fashioned aspect, it would appear that Mr. Ford is wrong. The B.Sc. with honours has, because of this, no better prospects than his companion who failed to satisfy the examiners, because the very fact that a man has passed his examination is likely to mislead himself into believing that industry is clamouring for him because of his degree. We believe Mr. Ford would describe that as "headache thinking." His advice is to attach oneself to any job, examine its potentialities with a clear brain, and either carry on or clear out into another.

With Mr. Ford's views on this subject we are in complete agreement, for it is a direct result of the replacement of philosophy by psychology. The philosopher used to say something about if any man could make two blades of grass grow where one previously sprouted, the world would make a pathway to his door. That required interpretation in an imaginative sort of a way. Mr. Ford says in effect, manufacture something for which there is a real need, and make the fulfilling of this your life's work. Accomplish it by the best methods available, which include maximum production from both machine and man. Both necessitate complete elimination of all waste, and the latter by paying very high wages, so as to create a high purchasing power amongst the operatives. Mr. Ford has a large number of foreigners in his works who are being trained in these basic principles, so that the Chinese, Persians, the Portuguese and Greeks will be paying something approaching an American standard of wages to its men, and so increase purchasing power for his automobiles. One can readily imagine how overseas markets can be developed in this way, and not only Mr. Ford would benefit, but so would every other manufacturing company.

Another precept is short hours, so that people will have leisure to spend time in the cultivation of hobbies and to pursue intellectual studies. This, of course, all helps to create a demand for a higher standard of living, and the potentialities for the live manufacturer to meet any demands so created.

After carefully reading the book, with its scant quotations of proverbs, one receives the impression that the Ford ideal is simplicity itself. Primarily he has no use for traditions, professional financiers, or political agitators. He admits of but one master, and that is the public he strives to serve. The testing time for any concern is when it is doing well, because these conditions present an opportunity for the amassing of money, by the sale of the organisation to the public, whereafter the management is faced with

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two masters, one requiring dividends and the other service in the way of cheap, high-class goods. Mr. Ford is machine mad. Every job has to be machine made. This he has carried out to such an extent that he has created for himself the problem of ensuring an adequate supply of tool-room mechanics.

It is interesting to read in this book the application of his methods to industries other than the manufacture of motor cars. He describes the purchase of a railway, of mines, and of other interests. He cleans up the property, pays everybody the Ford wages—six dollars a day—and makes everybody work hard. For instance, station masters may be found sweeping platforms or painting the booking hall. Apparently this simple system pays everybody, especially Mr. Ford, who having now sold 30,000,000 motor cars, is worth £170,000,000. We strongly recommend our readers carefully to study Mr. Ford's book, as in it they may find a solution to their own problems.

Institute of British Foundrymen.

Junior Section Formed at Birmingham.

Birmingham has followed the lead of Newcastle and Manchester in the formation of a Junior Section to comprise youths engaged in the industry between the ages of 16 and 23.

The meeting at which the decision was arrived at was convened by the Birmingham, Coventry and West Midlands Branch of the Institute of British Foundrymen, and held under the chairmanship of Mr. D. H. Wood last Saturday. The aim of the Junior Section is to bring the members together in order to improve their knowledge of the foundry and allied trades by reading and discussing papers and by visits to works. The subscription is to be 5s. per annum.

Mr. Wood recalled that it was in Birmingham that the Institute was founded and said that what the Institute had done for foundrymen in general they were anxious now it should do for the juniors. Urging the young men in the trade to join the Section, he pointed out that it was much easier to acquire theoretical information early in life than later on. In his opinion there was no industry which presented better prospects and opportunities than iron founding. There were important executive positions to be filled and the outlook for young men who by their education and experience were qualified to fill them was most encouraging.

Mr. T. Makemson, of Manchester, described the initiation and progress of the Lancashire Junior Section. He said that during less than a generation the trade had become a science as well as a craft, and he could not help remembering that much of the work which had helped to build up modern foundry practice on a scientific basis had been done in Birmingham. It was Prof. Turner who with his wonderful research into the behaviour of silicon laid the foundation of cast-iron metallurgy. He thought it must be admitted that up to the present the schemes evolved had not quite succeeded in solving the problem of attracting people into the foundry and of training them when they had been secured. Many firms had admirable schemes for training their apprentices; many technical institutions had arranged courses specially for foundrymen, yet somehow they had not produced a sufficient number of well-trained foundry apprentices. The failure was usually attributed to that somewhat nebulous thing—the indifference of the foundry apprentice himself. There probably was a certain amount of indifference, but he did not think the foundry apprentice could be blamed. If there was indifference it was because the foundry worker did not realise the potentialities of his job. The average apprentice did not realise that the foundry trade held very considerable prizes. He did not quite see the ladder between himself and the high positions. If he interpreted aright the function of the Junior Section it was to quicken the interest of the apprentices in their job, to help them to realise what exactly were its potentialities, and to make them see that foundry practice was much more than making moulds. They should be allowed to see something of the working of the cupola, to understand the functions of blast pressure, what constituted bad and good coke, why various grades of iron were used and why certain irons differed from others. They might also with advantage know something about the influence of the various constituents of iron and see something of non-ferrous foundry practice, as well as why moulding machines were economically sound under certain conditions. If they had a little information on these subjects their interest was aroused, they realised that they were engaged in a fascinating job, that if certain people filled the higher positions there was a reason for it, and that if they wanted to make progress they must learn all they could. The Junior Section, he believed, would meet the existing need.

Mr. Makemson went on to explain the steps taken in the formation of the Lancashire Junior Section, mentioning that they had the goodwill and co-operation of the two engineering employers' associations governing the Manchester area. At the opening meeting there were 240 people present, and 170 members were enrolled. At the end of the session the membership totalled about 250. He also touched on the methods of working, and concluded with a strong appeal to the young men in the trade to join up.

Mr. F. K. Neath (hon. secretary) submitted the proposed constitution of the Section, and the Chairman announced that letters in encouragement of the project had been received from Messrs. Belliss & Morcom, the Austin Motor Company, the British Thomson-Houston Company, the General Electric Company, and W. & T. Avery, as well as from the Principals of the Birmingham, West Bromwich and other technical schools.

Mr. F. J. Cook, in proposing that a junior section be formed, thought there was every advantage to be gained in "catching them young." He had always been in favour of education for the young men in the foundry trade, because he believed that the training received during apprenticeship days was even more important than that of one's school days.

Mr. Greenway, in seconding, emphasised the advantages to be derived from the Section, and Mr. F. C. Edwards said the discussions would stimulate thought and help to build character. The fact that membership of the Section would give the young men the entry to the Branch meetings was of great importance, because they would there meet men who were at the head of the craft.

The resolution was carried.

Mr. A. J. Lewis, in proposing a vote of thanks to Mr. Makemson, commented upon the extent to which pattern makers filled the highest positions in foundries. Probably 80 per cent. of the foundry managers up and down the country were pattern makers, he said, and he wondered why moulders allowed that predominance to continue. He spoke of the attractive positions open to men of integrity possessing the necessary knowledge, and urged the young men to learn to read drawings.

Mr. H. J. Roe seconded the motion, and paid a warm tribute to Mr. Makemson's work.

The motion was cordially endorsed by the meeting.

In reply, Mr. Makemson gave some particulars of the John Wilkinson medal examination which had been instituted as a stimulus to members of the junior section in Lancashire. "Your Section," he added, "starts its career with the very best wishes of the Lancashire Branch and of the Lancashire Junior Section."

It was decided that the night of meeting should be Saturday, and the hour 6.30. The Chairman mentioned that Mr. F. J. Cook had promised to give an elementary talk on cast iron at the opening meeting of the Junior Section.

Foundry Statistics.

Belgium and Luxemburg in June imported 15 tons of castings from Great Britain and exported 180 tons. From all countries they imported 694 metric tons and exported 2,594 tons.

In August France imported 207 metric tons of castings and exported 19,955 tons.

The Condition and Influence of Sulphur in Cast Iron.

By J. E. Hurst.

Whilst the importance of the influence of sulphur in grey cast iron has been realised for many years, the character of the importance attributed to this element has gradually changed with the more complete understanding of the many other factors which influence the properties of grey cast iron. Even yet there is a great deal of uncertainty both as to the mode of existence and the precise influence of this constituent in ordinary grey irons. Many of our leading metallurgists show a grave concern at the inevitable increase in the sulphur content of castings which must result from the continued remelting of scrap cast iron. Dr. Moldenke has drawn attention to this in the United States, and a great deal of attention is being paid to the question of the desulphurisation of cast iron by various Continental, particularly German, investigators. From a commercial point of view, as a constituent of pig-iron, sulphur ranks next in importance to silicon. Existing buyers' specifications demand comparatively low sulphur content for ordinary foundry pig-irons, and any increase beyond these low figures is a powerful argument for a reduction in price which the blast-furnace owners are unable to resist. This state of affairs might be partially due to traditional prejudice, but there is no doubt that it is mainly due to the uncertainty of the influence of the constituent, the conditions and limits, if any, under which the presence of this element is dangerous.

The modern tendency towards the extended use of low total carbon content pig-irons will result in a steadily increasing demand for such irons at prices more comparable with existing foundry irons. The sulphur problem is very likely to hinder the development along these lines. In many of the methods available for the production of such low total carbon irons an increase in the sulphur content can only be prevented by the use of a desulphurising process of some kind. On the other hand, a demand for low sulphur-content in such irons might only be capable of practical solution by the use of open-hearth or electric-furnace melting, where the sulphur-content can be controlled. Whatever the method followed, if it becomes necessary to prevent the increase in sulphur-content, the cost of production of the pig-iron must, of a certainty, be increased, a fact which is sure to hinder the development in the production of low total-carbon irons at a low cost. There is no doubt that it is eminently desirable to review our knowledge of both the influence and mode of existence of the sulphur in cast iron, and in any event such a review will serve a useful purpose in counteracting many of the gross mis-statements which are still only too common regarding the influence of this element. In making this review it appears desirable to consider first of all the manner in which sulphur does and may exist in cast iron, and finally to consider the influence of the sulphur on the useful properties of cast iron in the light of this knowledge.

Compounds of Sulphur Present in Iron Alloys.

It is now well known that sulphur is met with in iron and its alloys in two forms as chemical compounds of iron and manganese—iron sulphide, FeS, and manganese sulphide, MnS, respectively. It has been suggested that other compounds may exist. A compound sulpho-silicide of iron, containing both sulphur and silicon, has been suggested, and the possibility of sulpho-carbides has also been discussed. The evidence for the existence of such compounds is very slight and meagre. The possibility of the existence of sulpho-silicides has been based on the presence of sulphur and silicon in the electrolytically-separated residues from dissolved steels. The existence of the latter compounds has been suggested as an explanation of the effect of annealing drillings and its influence in giving a more uniform and higher result in the volumetric estimation of sulphur. The presumption of such complex sulphur compounds on such flimsy evidence has never been justified, and the possibility of their existence is regarded in these days as being extremely remote.

The investigations of the simple binary-equilibria of manganese and sulphur and iron and sulphur respectively are extremely difficult, and the results are seriously vitiated by the presence of oxides and silicates, which it is extremely difficult to prevent in preparing the alloys for investigation. This fact has a great deal to do with the uncertainty surrounding the influence and mode of existence of the sulphides in cast iron.

Iron and Sulphur.

The iron-sulphur system has been investigated by Treitsche and Tamman* and Friedrich,† and partially by various other investigators. Treitsche and Tamman found that the results obtained were subject to the difficulty of obtaining alloys free from oxides and silicates. The presence of such impurities introduces a lack of miscibility into the system. The final diagram as constructed is illustrated in part in Fig. 1. The iron-rich end of the diagram only is illustrated.

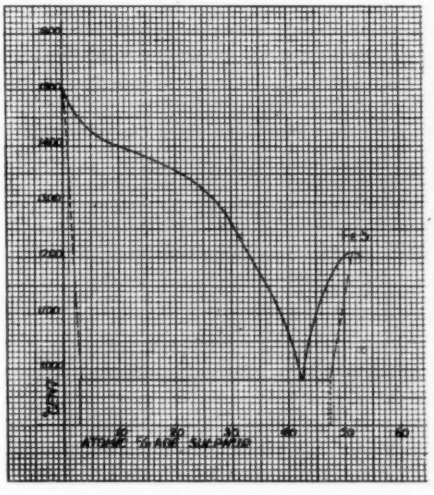


Fig. 1.—Fe – FeS Diagram (Tamman and Treitsche).

The existence of the compound FeS is confirmed, containing approximately 37.5 per cent. sulphur. This compound has a melting point of 1,180 deg. C., and its specific gravity is given by Holman as 5.02. The molecular heat of formation of FeS is given as 24,000 calories. There is a slight variation in the values recorded for the melting point of FeS, other values being given, *e.g.*, 1,171 deg. C. and 1,188 deg. C. The above value of 1,180 deg. C. is a mean value and sufficiently accurate for all practical purposes.

The existence of a binary-eutectic containing FeS is revealed by the diagram at a concentration of 42.5 atoms per cent. sulphur and a temperature of 970 deg. C. There is again a slight variation in the concentration and temperature of this eutectic on the part of different observers. Friedrich finds a concentration of 85 per cent. FeS and a temperature of 983 deg. C. Stead finds a concentration of 85 per cent. FeS and a temperature of 960 deg. C., and McCance gives the eutectic temperature of 980 deg. C.

There appears to be some doubt as to the extent of the solubility of FeS in Fe. The diagram Fig. 1 shows the saturated solid solution at a temperature of 980 deg. C. as containing approximately 3 atoms per cent. sulphur in solution. Guia states that FeS is soluble in α iron in such quantities (less than 1 per cent.), and Tamman found that in the presence of oxide of

* Zeitschrift Anorganische Chemie, 49,320, 1906.

† Metallurgie, 7,257, 1910.

iron the quantity of FeS which dissolved in the γ iron is greater and a lowering of the β arrest point is produced. In the presence of oxide of iron the transformation (eutectoid Fe-FeS) which occurs at 298 deg. C. is absent. Ordinarily the A3 and A2 points are stated to be uninfluenced by the sulphur. Stead states that the solid solution contains 3 per cent. FeS, and that this is deposited on passing through the change point at 130 deg. C. Whatever the extent of the solubility of FeS and α (alpha) iron may be there is no doubt about its solubility in molten iron and in γ iron to a considerable extent. The most that can be said about its solubility in α iron in the light of our existing knowledge is that it is slightly soluble. This appears to be definite. Further confirmatory evidence of the solubility of FeS in iron is to be had from the investigations of Wüst in connection with shrinkage. Wüst found that the influence of sulphur on the shrinkage was identical with that of other elements which are soluble in iron, and which exert a considerable lowering effect on the total shrinkage value of pure iron.

Manganese and Sulphur.

Very little is known regarding the manganese-sulphur system, which, probably more so than the iron-sulphur system, is affected by the presence of manganese oxides and silicates. The existence of the compound manganese sulphide (MnS) is well established and has been studied by Le Chatelier and Ziegler. This compound is readily oxidised at high temperatures, and it is due to this that the characteristic smell of sulphur dioxide (SO_2) is noticed when handling sulphury iron.

The melting point of manganese sulphide has been a matter of some doubt. The careful results of Rohl, who obtained a melting point of 1,620 deg. C., are now accepted by metallurgists. The lower temperatures of 1,400 deg. C. given by earlier workers are considered to be due to the presence of manganese oxide. McCance states that with 9 per cent. MnO, manganese sulphide can be quite easily fused at a temperature of 1,400 deg. C. The authoritative value of 1,620 deg. C. for the melting point of manganese sulphide is considerably above both the melting points of manganese and iron, which are 1,247 deg. C. and 1,505 deg. C. respectively. The specific gravity of manganese sulphide is variously given as 3.966 and 3.99. The latter value is due to McCance. The molecular heat of formation is given as 45,600 calories.

Manganese Sulphide and Iron Sulphide.

The system manganese sulphide—iron sulphide has been carefully investigated by Rohl*, whose results are expressed in the constitutional diagram Fig. 2. The system shows a eutectic at a concentration of 60 per cent. FeS and 40 per cent. MnS and a temperature of 1,175 deg. C. approximately. This eutectic, according to Rohl's diagram as drawn, consists of FeS and the complex compound 3FeS 2MnS indicated by the vertical line in the diagram. Most metallurgists are agreed that it is better to interpret this compound as the saturated solid solution of FeS in MnS containing 40 per cent. MnS, and the diagram would be more rationally drawn by joining the points BD and eliminating the line BA. Under these conditions the line BD represents the approximate solidus line for this portion of the system. The point B under these circumstances represents the saturated solid solution of MnS and FeS containing the above-mentioned percentages of the two constituents and which happen to coincide with the simple formula 3FeS 2MnS. Whether there is any reduction in the mutual solubility in the lower ranges of temperature is not known.

Iron Sulphide in Alloys Containing Carbon.

The investigation of the complete ternary system Fe-FeS-Fe_3C has never been done, and our knowledge of the mode of existence of iron sulphide in iron in the presence of carbon is limited on this account. Much of the work which has been done can be regarded as a partial study of this system, but in many cases the conclusions are vitiated as a result of the uncertainty of the freedom of the alloys used from manganese and silicon.

In the absence of manganese and silicon Levy† considers that a ternary, iron carbon-sulphur eutectic exists in the system consisting of a solid solution + Fe_3C + FeS, and having a melting point of 1,130 deg. C. Dr. Stead has also recorded this same eutectic. The actual composition of this eutectic is not known with certainty. Levy states that in alloys containing less than 0.8 per cent. sulphur no sulphide is found in the pearlite areas. The evidence on which this observation is based is not very clear, and it would appear that microscopical evidence alone was relied upon. It is obvious that this

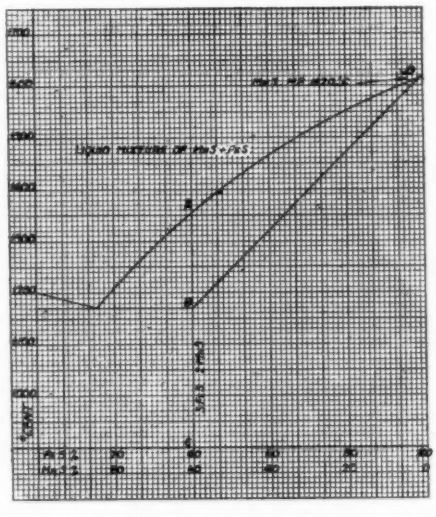


Fig. 2.—Rohl's FeS + MnS Diagram.

evidence would fail to identify sulphide dissolved in the pearlite areas, as such dissolved sulphide would not be visible as a separate constituent. There is no doubt that the pearlite which results from the resolution of the solid solution portion of the above eutectic must contain sulphide dissolved in it.

The solubility of the iron sulphide in iron in the presence of carbon does not appear to have been thoroughly investigated. In the absence of carbon it is soluble to a limited extent as already mentioned. Piwowarsky states that FeS is completely soluble in liquid iron, and it is soluble up to 0.25 per cent. in both α and γ iron. It is presumed that Piwowarsky is referring to the solubility of FeS in the absence of carbon. Levy, in his observations previously referred to, records that in iron-carbon alloys containing 2.73 per cent. carbon the saturation point for sulphur is slightly less than 0.9 per cent. This observation is based on the fact that in those alloys containing less than 0.9 per cent. the sulphur was uniformly distributed throughout the specimens. With sulphur in excess of this figure the sulphur was aggregated in large globules, and more sulphur was present in the upper than in the lower portions of the melt. The saturation point here referred to is undoubtedly the triple eutectic point and not the saturated solid-solution, and Levy produced microphotographs of this eutectic showing the sulphide constituent very clearly.

Other attempts to determine the distribution of iron sulphide in iron-carbon alloys have been made by Hatfield and Stead, the method adopted being the examination of the electrolytically-separated carbide residues. Hatfield's experiments were performed in the presence of silicon and will be discussed in a subsequent section. Stead's experiment was performed on an alloy containing 1.89 per cent. silicon and 0.29 per cent. manganese and 0.27 per cent. sulphur and 0.10 per cent. sulphur was found in the separated carbide. In a further alloy containing not more

* Carnegie Research, J. I.S.I.

† J. Staff. I. & S. I., 1909-10.

than 0.5 per cent. silicon and free from manganese, the saturation point for sulphur was found to be 1.00 per cent. with 4.37 per cent. carbon. With this amount of sulphur, this alloy was very strongly hypereutectic, as demonstrated by Dr. Stead's microphotographs which show very large carbide plates. The amount of sulphur found in the separated carbides was 0.8 to 0.9 per cent. From this it is concluded that FeS is soluble in the carbide to the extent of approximately 0.10 per cent. The remainder of the sulphide exists in Dr. Stead's alloys, partly as FeS and partially in the solid solution portion of the eutectic.

Manganese Sulphide in Alloys Containing Carbon.

Levy considers that manganese sulphide is sparingly soluble in liquid steel and solidifies after the steel has become solid. He also considers that MnS is soluble in liquid cast iron up to 0.11 per cent. S or 0.30 per cent. MnS. Inferentially Levy agrees that MnS is insoluble in both α and γ iron containing carbon. In view of the melting point of MnS being actually much higher than Levy's determination and the likelihood of Levy's sulphides containing dissolved oxides, some doubt may be cast on the solubility of MnS suggested by Levy. From other observations the writer's opinion is very strongly confirmed that MnS is insoluble in iron containing carbide or, at any rate, its solubility is of an extremely minute order, very much less than the value given by Levy.

Iron Sulphide in Irons Containing Carbon and Silicon.

The effect of the presence of silicon in the ternary alloys of iron-carbon and sulphur on the condition and distribution of the iron sulphide is not concisely known. Wth the presence of sufficient silicon the ternary eutectic of iron-carbon and sulphur is non-existent, but what effect the silicon has on the solubility of the FeS in both the austenite and the carbide or the decomposition products is uncertain.

Hatfield has studied the influence of sulphur in iron-carbon alloys containing silicon with the absence of manganese. Hatfield prepared alloys containing up to 0.83 per cent. sulphur and with silicon up to 1.03 per cent. In all his samples Hatfield observed free sulphide, but it is recorded several times, particularly in reference to the high sulphur samples, that nothing like the amount of FeS one would have expected could be seen under the microscope. As stated by Professor Carpenter in the discussion on this Paper, the free sulphide cannot be detected in the microphotographs as printed, but there is no doubt that a considerable proportion of the iron-sulphide must exist in solution. The carbide residues were examined and found to contain some sulphur. In a series of earlier experiments this same investigator found that the carbide residue of an iron containing 3.16 per cent. total carbon, 0.97 per cent. Si, 0.45 per cent. S, contained no sulphur, the absence of which was considered to be due in some manner to the silicon present. Whilst there appears to be no quantitative evidence, there is no doubt that even in the presence of silicon a considerable proportion of the FeS is soluble in iron in the presence of carbon, and, furthermore, it appears unlikely that FeS is soluble to any very appreciable extent in the carbide when silicon is also present.

Sulphur in the Presence of Both Silicon and Manganese.

We now have to consider the presence of sulphur in iron-carbon alloys containing both silicon and manganese. Such alloys are typical of everyday commercial cast irons which contain all these constituents. All the evidence which we have tends to show that sulphur in the condition of manganese sulphide is insoluble in the liquid iron. This evidence generally takes the form of observations of the segregation or the movement of this constituent during the solidification of liquid masses of iron. A typical example of this is illustrated in Fig. 3, which is a sulphur print taken from the cross-section of a round bar of cast iron 4½ in. dia. × 16 in. long. This bar was cast in a metal mould, bottom-poured from a point near the bottom. The extensive segregation of the sulphide constituent, particularly in the top portion of the bar, which was open, is very clearly indicated. This is good evidence of the insolubility, and also the lower specific gravity of the manganese sulphide. Still more conclusive evidence has been previously

Fig. 3.—Sulphur Print from Cross Section of Cast-Iron Bar, 4½-in. dia. × 17-in. long. Quarter actual Size.

recorded by the writer from observations made of centrifugal castings of comparatively large masses of cast iron. The segregation of the manganese and sulphur take place very distinctly under the influence of centrifugal action, and the direction of movement is towards the centre of the rotating mass. This is absolutely direct confirmation of the insolubility and lower specific gravity of the manganese sulphur compound. Furthermore, the quantities of manganese and sulphur which take

part in this movement are very close to the requirements of the formula MnS, which may be taken as tangible evidence that the manganese sulphur compound is actually the MnS. In the above experiment a very small quantity of sulphur, namely, 0.06 per cent., remained unsegregated in the outer portions of the castings. It was assumed in the calculations that this existed as MnS, and its failure to separate along with the remaining MnS was due to the fact that the metal was not retained molten sufficiently long under the centrifugal action. This was not confirmed by any further examination, and there is always the possibility to be considered that this amount of sulphur may exist as FeS in solution or may be MnS in solution and represent the limit of solubility of MnS in the particular siliceous iron. Further experiment is needed to decide this point. We have in these experiments, however, very conclusive evidence that the manganse sulphide exists as MnS, is insoluble and of a lower specific gravity than the rest of the iron. The condition under which this experiment was made in so far as manganese is concerned is that there was a considerable excess of manganese, viz., 0.23 per cent., over that required to form the compound MnS. Under these conditions there was no trace of the double compound or, preferably, the saturated solid solution of MnS in FeS represented by the formula 3FeS 2MnS.

In the presence of manganese, iron sulphide present in cast iron exchanges sulphur with manganese in accordance with the equation:—

$$FeS + Mn = MnS + Fe.$$

Considerable doubt has been expressed as to the completeness or otherwise of this reaction in the presence of excess manganese. From a practical point of view it is observed that a considerable excess of manganese over the theoretical requirements of MnS (viz., 1 part of sulphur to 1.73 parts of manganese) is required. According to Stead, as much as eight times the theoretical requirements of manganese are necessary to ensure the complete formation of MnS.

In support of the above reaction being reversible in character, the experiments of Schutz are cited by Levy. This investigator heated together Mn and FeS in the proportions represented by the above equation to a temperature of 1,500 deg. C. Instead of wholly MnS and iron two distinct products consisting of a solution of manganese in iron and manganese sulphide containing 11.5 per cent. iron resulted. When MnS and iron were heated together presumably to the same temperature the iron absorbed about 10 per cent. Mn and the MnS about 4 per cent. iron. It is assumed that this could only have taken place in accordance with the following equation, the reverse of the previous one:—

$$MnS + Fe = FeS + Mn.$$

Further experiments have been made recently by Herty and True.* In these experiments manganese sulphide and iron sulphide were added to various samples of molten electrolytic iron under such conditions that the final melt contained an excess of manganese. It is claimed that the results show that manganese sulphide even in the presence of excess of manganese. will be converted into iron sulphide and enter the metal. Hence the reaction expressed in the first of the two above equations should be regarded as reversible. The importance of these results is lowered very considerably by the presence of oxygen. All the results show a considerable loss in Mn between that added and that shown in the final metal, the loss amounting to as much as 33.3 per cent. Herty and True themselves explain this as due to the amount of oxygen contained by the electrolytic iron, which they state as amounting to 0.44 per cent. Furthermore, the addition of solid MnS, which has a melting point of 1,650 deg. C., to molten iron, which in Herty and True's experiments was probably at a lower temperature than this, and was only 1,500 deg. C. in Schutz's experiments, is likely to be attended by considerable oxidation. When the influence of oxide of manganese on the melting point of MnS is taken into consideration, it will be appreciated that the reactions involved in Herty and True's experiments are probably more complex than represented by the above simple equations. Finally, it should be noted that in the composition of the final alloys, in spite of the oxidation, sufficient of the manganese is left to correspond to the requirements of the compound MnS. (See Table I.)

* F.T.J., March 26, 1925, page 272.

Table I.

Run	Material Charged.	Charged Per Cent.		Actual Per Cent.		Mn Requirements for MnS Per Cent.
		Mn	S	Mn	S	
2	MnS+Mn	1.0	·452	0·636	0.367	0.63
5	FeS + Fe	1.0	·50	0.647	0.397	0.68

None of these experiments gives us satisfactory and conclusive evidence of the reversibility of this reaction, and in cast irons containing such large quantities of carbon and silicon the influence, if any, of MnO can be disregarded, as it is not likely that MnO can exist under these conditions.

The conclusions of McCance from his experiments and those of Dr. Stead that the reaction is not a balanced one, undoubtedly expresses the facts as we know them, and his explanation that a portion of the manganese is invariably associated with some other element, namely, the carbon, is sufficient to explain the necessity for excess of manganese over the theoretical requirements to convert the whole of the sulphur to MnS.

Conclusions.

We may therefore conclude that in the presence of sufficient manganese the whole of the sulphur is converted into manganese sulphide and that the possibility of the existence of FeS under these conditions is nil. We may also conclude that under the same conditions of sufficient manganese the saturated solid solution of FeS and MnS corresponding to 3FeS 2MnS does not exist.

The excess over the theoretical amount of manganese required to convert the sulphur to manganese sulphide is a matter which is of vital interest to the foundryman. As already stated, Stead has given a ratio of 8 to 1. This is in connection with steel, and in so far as steel is concerned the experience appears to vary very considerably, ratios of 5 to 3 and 4 to 1 having been given by other observers. The classical steel of Brinell containing 0.56 per cent. S and 1.89 per cent. Mn, a manganese-content very close to the theoretical requirements was shown to have all the sulphur existing in the harmless condition. As in the case of steel, the experience varies in connection with cast iron. The case previously quoted shows that 0.23 per cent. sulphur is completely converted to MnS in the presence of 0.60 per cent. manganese, a ratio of 2.6 to 1. It does appear likely that the ratio will be influenced by the proportion of silicon present, and the ratio might be expected to be higher with lower silicon contents.

(*To be continued.*)

On behalf of the liquidation department of H.M. Treasury the Pembrey munition works, near Llanelly, comprising 771 acres of freehold land, together with plant, machinery, buildings, etc., were sold by public auction at Swansea on Tuesday, the entire lot being purchased by Edgar G. Rees, Limited, tinplate and scrap metal merchants, Bryn Works, Llanelly, for £30,000.

The contract which has been entrusted by the High Commissioner for India with Gwynnes Engineering Company, Limited, Hammersmith Iron Works, London, for the provision of the pumping plant required in connection with the construction of the Lloyd Barrage of the River Indus at Sukkur, was placed after a thorough investigation, at a price substantially above that of other competitors. The plant consists of thirty-three sets of 8-in. electrically driven sand pumps, with pipes, valves, flexible joints and motor-driven primary units. This equipment, which will be afloat on eleven steel pontoons each mounting a battery of three with their accessories, switch-gear units, etc., will drain the water, which may be heavily charged with sand, from the coffer dams. The electrical sub-contracts are being carried out by the English Electric Company. In the face of severe foreign competition the same firm have just shipped eleven of their "Invincible" light motor fire engines in fulfilment of orders from Japan.

Methods for Determining the Properties of Cores Made with Cereal Binders.*

By H. L. Campbell, Ann Arbor, Mich.

Cereal products have been used as sand binders from the earliest periods of foundry operations. Within recent years, new products, obtained mainly from corn, have been placed on the market and have found extensive use as core binders. The chief characteristic of these materials is their bonding action produced both before and after baking the sand mixtures. A cereal binder is often used with other binders in making cores, because of its property of sticking the sand particles together before the cores are baked.

An important consideration in the selection of core binders is the cost per unit of bonding strength. In many applications cereal binders have the advantage in this respect. As all cereal binders are marketed on the basis of weight, it is important that these materials be used in core sand mixtures on the same basis when comparative results are required. It has been found that the commercial cereal products vary considerably in weight per unit of volume.

In order to determine the relative values or most economical practice in the use of cereal binders, methods must be available for measuring the properties of cores made with these materials. It has been necessary to develop a method for determining quantitatively the bonding action produced by core binders before the cores become strengthened by heating. Also, a method for measuring the effects of cereal binders on the permeability of cores was required in the investigation of these materials. For obtaining the strength of baked cores, test specimens 1 by 1 by 8 ins. were made in a uniform way, and after baking for definite intervals at specified temperatures were broken transversely on supports 6 ins. apart. It is well to point out the necessity for accurate control of the baking process when making comparative tests of core binders. Radiated heat should be avoided and provision made for obtaining uniform temperatures throughout the heating space.

Method for Measuring the Green Bond of Core Sand Mixtures.

The property of cementing the sand particles in a core sand mixture before the cores are baked is known as green bond. In all cases where intricate cores are made or where considerable handling of cores is necessary before the cores are hardened by baking, this property is of fundamental importance. On account of the relatively low strength of all core mixtures before baking, the preparation and handling of ordinary test specimens of green cores are exceedingly difficult operations. Methods which can be used for measuring the bond of moulding sands may be unsuited to the measure of this property in core sand mixtures.

The method which has been found most satisfactory for determining the values of green bond in core sand mixtures consists of forcing a core of definite shape into a core of standard size and measuring the load required to displace a given volume of the core body. The action produced by the core is to disrupt the sand particles and thereby separate the core into two or more parts. The more firmly the particles of sand are held together the greater will be the load required to separate the components of the mixture.

Green Bond Testing Machine.

The construction of the green bond testing machine is shown in Fig. 1. It consists of a frame made of ¾-in. angle steel to which is attached a

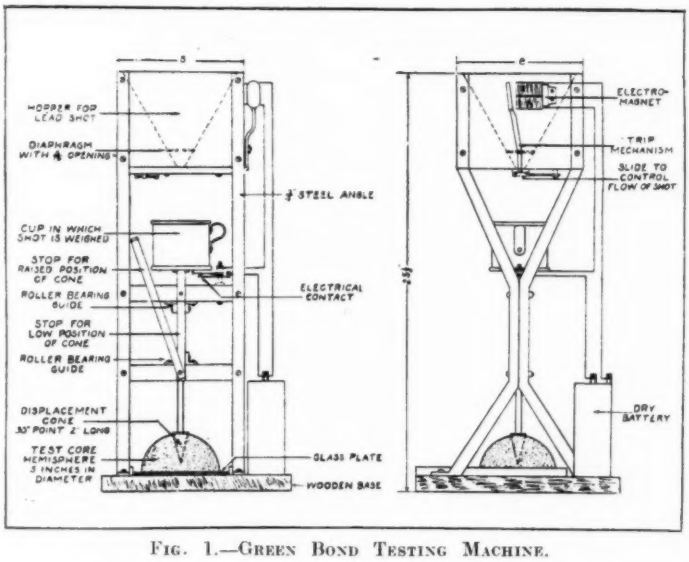


Fig. 1.—Green Bond Testing Machine.

wooden hopper and two wooden cross plates. At one end of a piece of ¾-in. aluminium tubing is an aluminium cone having an angle at the point of 30 degs. To the other end of the piece of tubing an aluminium disc is fastened to serve as a support for an aluminium cup. This unit is guided vertically by two roller bearings which are secured to the wooden cross pieces.

The load is applied to the cone at a constant rate by a lead shot dropping from the hopper into the cup. A slide is provided below the opening in the hopper to control the flow of shot. In order to permit free movement of the slide, a diaphragm is placed in the hopper, having an opening somewhat smaller than the opening at the bottom of the hopper. The flow of shot is stopped instantaneously when the cone penetrates the test core a distance of 2 ins. By means of an electrical contact, the circuit through an electromagnet is closed, and this actuates a trip mechanism which closes the opening in the hopper. In order to protect the point of the cone, a stop is provided for the low position of the cone. Also a stop is used to support the moving unit in its raised position.

Green Bond Test Cores.

It is necessary to make the test cores in a uniform manner. For this purpose, a core box

* A Paper read before the Detroit meeting of the American Foundrymen's Association.

having a hemispherical opening 5 in. dia. is clamped to another box with a cylindrical opening 5 ins. dia. and 3 ins. high. This assembly is mounted on a core-making machine, and the sand mixture is jarred into the hemispherical cavity by 10 blows of the core-making machine. After cutting off the excess sand, the core is turned out on a glass plate which is 6 by 7 ins. The plate with the body of sand is then placed on the wooden base of the green bond testing machine so that the point of the cone is directly above the centre of the hemispherical core. The cone is lowered gradually in to the green core and the flow of shot is started. On the completion of the test, the weight of the cup and shot in the cup is determined, and to this is added the weight of the moving unit. The values of green bond are expressed in grams.

Results of Green Bond Tests.

The values for green bond of core sand mixtures prepared with cereal binders vary with the proportions of water used in the mixtures. Some results of green bond tests are given in Table 1.

Table I.—*Green Bond Values in Grams.*

Water added in cc. ..	70	140	210	280	350	420
First Test ..	752	1,039	1,101	1,156	1,201	too
Second Test	760	1,001	1,064	1,140	1,214	wet to
Third Test ..	729	1,016	1,056	1,116	1,231	make
						cores.
Average ..	747	1,019	1,074	1,137	1,215	

A mixture of 2,250 grams (1,500 c.c.) of 60- to 70-mesh Michigan City sand and 45 grams (about 70 c.c.) of a cereal binder was used in the tests reported in Table I. These data indicate that the green bond increases with additions of water until the mixture becomes too wet to be used in core boxes.

In Table II will be found green bond values for core sand mixtures prepared with different cereal binders. A ratio of 1 part by weight of cereal binder to 50 parts by weight of 60- to 70-mesh Michigan City sand was used in obtaining these data. The volume of water used in preparing the green sand cores was four times the volume of binder.

Table II.

Binder designation ..	A	B	C	D	E
Average Green Bond Values in Grams ..	1,118	1,192	1,187	1,267	774

Method for Measuring the Permeability of Cores.

One of the important requirements of dry sand cores is the provision for venting the cores. This property, which is a measure of the rate of flow of gases through porous bodies, is known as permeability.

The permeability of cores is generally of greater importance than the permeability of other parts of moulds. In many cases the cores are almost completely surrounded with metal and the areas through which gases can escape from the cores are relatively small. Therefore the permeability of cores must be sufficient to allow the gases which are produced by contact of the molten metal with the cores to escape freely. Otherwise, these gases will be forced into the metal, causing defects in the castings.

The apparatus used in measuring the permeability of dry sand cores is shown in Fig. 2. It consists of a cup in which a test core is placed, an air holder such as used in the A.F.A. standard test for determining the permeability of moulding sands, and a connecting between these units. Mercury is put into the cup around the test core so that the air which is delivered from the air holder cannot pass around the core. As a core will float in mercury, it is necessary to hold the test core down with a weight. By means of a brass sleeve which fits tightly over the rubber stopper on the air holder, the air supply is connected to the cup with rubber tubing.

Permeability Test Cores.

The outside dimensions of permeability test cores are 3½ in. dia. and 1½ in. high. At the centre of one side of each core is a cavity 1¼ in. dia. and ½ in. deep. These cores are made in a core box which is attached to a core making machine. The core sand mixture is jarred into the core box by allowing a head of 3 in. of sand to fall 10 times from a height of 12 in.

Making a Permeability Test.

A test core is put into the cup, the weight is placed on the core and mercury is poured around the core until it overflows through the small tube on the side of the cup. The operation of the air holder is the same as used when making permeability tests of moulding sands. After turning the indicator on the valve to VNT, raise the bell to the mark X on the wall of the bell. Then turn the indicator to OFF, and the bell will remain in its raised position. When ready to start the test, turn the indicator to ON, and the bell will lower as the air is forced through the core. With the aid of a stop watch, the time in seconds required for the bell to lower from the O mark to the 2,000 mark is obtained. The water levels in the manometer are noted during the test.

The values for permeability are inversely proportional to the time required for a definite volume of air to pass through a definite thickness of core. In order to have numbers which can be readily compared, permeability values are obtained

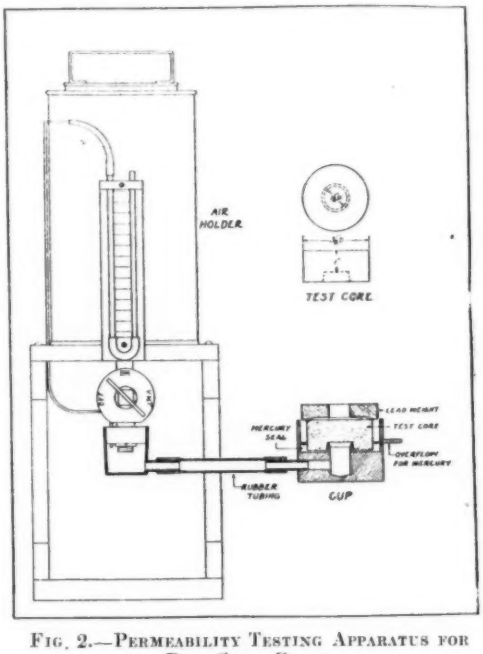


Fig. 2.—Permeability Testing Apparatus for Dry Sand Cores.

as the quotient of 100 divided by the number of seconds found during the test.

The air leakage in any part of the apparatus may be checked by placing a rubber stopper in the centre opening within the cup and noting the change in level of the bell during a 5-min. interval.

Results of Permeability Test.

The results obtained in measuring the permeability of dry sand cores by the method described above are reliable, because there is no possibility of the air supply short-circuiting around the core during a test. Furthermore, there is little chance of damaging the test cores during baking, because the section through which the air passes is protected.

In order to determine the accuracy of the method six test cores were made from each of a number of different batches of core sand. The

Table III.

Binder designation ..	A	B	C	D	E
Average permeability..	4.2	4.6	3.2	5.0	5.3

following figures are typical of the results obtained—time in seconds; first core, 10, 10, 10; second core, 10, 10, 10; third core, 11, 11, 11; fourth core, 10¼, 10¼, 10¼; fifth core, 10¼, 10¼, 10¼; sixth core, 11, 11, 11. The average permeability value for these cores is found by dividing 100 by 10.4.

In Table III are given the average permeability values for cores made with commercial cereal binders in the ratio of 1 part by weight of binder to 50 parts by weight of 60- to 70-mesh Michigan City sand. It is apparent from these data that some binders have a greater tendency than others to obstruct the gas passages in dry sand cores.

Dry Bond Strength of Cores Made with Cereal Binders.

The bonding property produced by cereal binders can be determined most satisfactorily by transverse tests of cores which are made and baked under definite conditions. Methods and equipment for making test cores in a uniform manner and for measuring the breaking loads are described in the A.F.A. Transactions for 1926.

In order to obtain maximum results from cereal binders, it is necessary to use sufficient water in the preparation of the mixtures to dissolve and distribute the binder uniformly throughout the sand. The exact amount of water to be added will depend upon the condition of the materials used. As a general rule, the highest dry bond strength is obtained when the total water addition to dry materials is about four times the volume of the cereal binder.

The average transverse strengths of cores made with different cereal binders are given in Table IV. The test cores were made from mixtures containing 1 part by weight of binder and 50 parts by weight of 60- to 70-mesh Michigan City sand. In each test batch the volume of water used was four times the volume of binder. The cores were baked for 1 hour at 175 deg. C.

Table IV.

Binder designation ..	A	B	C	D	E
Average Transverse Strength in lbs. ..	41	48	31	53	32

Summary.

Methods have been developed for measuring the green bond of core sand mixtures and the permeability of dry sand cores. These properties, as well as the dry bond strength of cores, should be obtained when comparing the relative values of cereal binders or establishing the most economical practice in the use of any of the cereal binders.

Alpax.

In the Aeronautical Research Committee Report, No. 1011, Mr. H. J. Tapsell deals with the results obtained of some mechanical properties, at air temperature and at elevated temperatures, of cast silicon-aluminium bars ($1\frac{1}{2}$-in., 2-in. and 3-in. diameter) called "Alpax," supplied by Messrs. Lightalloys, Limited.

Results are given of the tensile tests, notched bar impact tests, brinell hardness tests, and fatigue tests under direct reversed stresses.

The report states that this material is a valuable casting alloy. The ultimate tensile strength compares favourably with that of chill-cast Y alloy, though inferior to that material in the heat-treated condition. The elongation is unusually high for a cast aluminium alloy. The tensile strength falls steadily with rising temperature. At 250 deg. C. the value—7 tons per sq. in.—is much lower than that of Y alloy as cast. At 350 deg. C. the value—4 tons per sq. inch—does not compare well with that of Y alloy—7 tons per sq. inch for material as cast and nearly 12 tons for cast heat-treated material. In the sand-cast state this material is only slightly inferior, and gives still a high elongation and tensile strength. Castings up to 3-in. dia. are only slightly inferior in mechanical properties to castings of 1-in. dia.

It is shown that the material is not free from casting defects. In this respect the 1-in. dia. chill-cast bars were least satisfactory, a number of them containing large cavities. The sand-cast bars were quite satisfactory. The bars of larger diameter, 2-in. and 3-in., were also on the whole satisfactory. The cavities detected in them were small for castings of such dimensions.

The fatigue range is fair for a cast aluminium alloy, but does not approach the results given by some heat-treated alloys.

Staffordshire Iron and Steel Institute.

The opening meeting of the session of the Staffordshire Iron and Steel Institute was held on Saturday, October 2, at the Education Offices, St. James' Road, Dudley, when Mr. Douglas H. Ingall, D.Sc., F.I.C., Principal of the County Technical College, Wednesbury, delivered his presidential address. In the course of it he said that the development of physical metallurgy during the last few years had been enormous, and the number of investigations which had been made was prodigious; but unfortunately the results were not completely available. It was probably true that a considerable percentage of the results of the academic researches had been published; it was undoubtedly equally true that only a minute percentage of the industrial researches had been made public property. Surely this was to be deplored? One was quite aware of the impossibility of industries publishing all their investigations, but there were many which were unfortunately withheld, and though it might be an achievement to know that a certain thing could be obtained, it was an equal achievement to elucidate a certain and practical way of doing it.

Referring to the problems of the iron and steel manufacturing industries, the President remarked that in the first place, whether a works was concerned with production or manufacture of iron and steel, it was using plant, and therefore the problems of plant and equipment would be part of the Institute's field of activities. It was then that probably they would be rubbing shoulders most of all with engineers, and some parts of those problems involving design such as rolls for a production works, cold heading machines for nut and bolt manufacturers, or a pilger for tube making, would be wholly theirs. But even there the metallurgist was not totally without count, for a knowledge of the mechanical properties of the materials, such as hardness, strength, plasticity, etc., over the range of temperatures at which they were to be deformed, and the effect of speed of deformation, must be essential for the engineer, to enable him to design the most economical and efficient machine to meet their needs. There must be a considerable quantity of knowledge of an empirical and practical character in this connection which had been obtained by practical observation, and would be most valuable to their science.

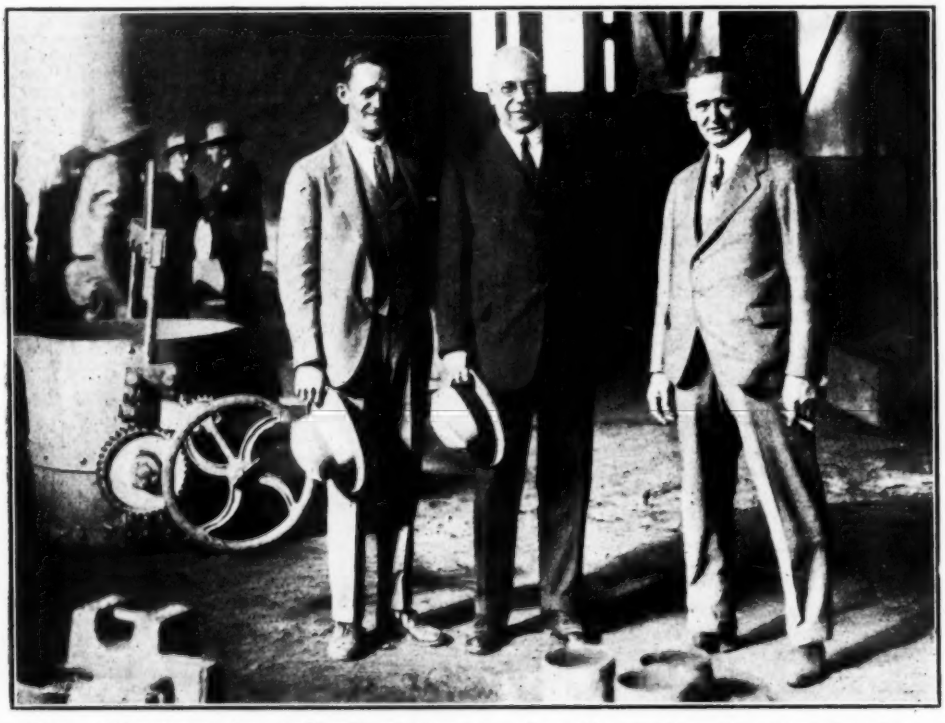
Secondly, in addition to plant there were the corresponding and involved processes. Here also they entered the field of both production and manufacture, although the former would, on the whole, have a wider scope and be entirely different from the latter. Papers and discussions on processes must, of their very nature, be largely, if not wholly, practical. Until fortune smiled again upon their iron and steel production works they could hardly expect to be favoured with practical process papers from them; but there was any amount of scope from the manufacturing side. The possibility of the elimination of a given operation, or operations, in the manufacture of a given article; the methods whereby processes might be modified towards the end of minimum scrap production; the condition of the materials which would admit of an expenditure of least power; these and other allied process problems were the daily concern of every manufacturing works, and was it not true that, without involving the sacrifice of anything vital, it should be easily possible for practical papers on those lines to be read and discussed at their Institute with mutual advantage all round.

In addition to the technical problems outlined, continued the President, there were those that belonged to a third field not one whit less important, a field which was ever growing, and which, unless handled with understanding and foresight might be an ever-increasing menace to any one industrial firm or works. For them, as metallurgists, there would be ever two goals: (1) The discovery of new materials, and (2) the more perfecting of those metals and alloys which we have already and know, and of the articles which we, or others, make from them. The domain of new discoveries probably would be generally confined to a relatively few centres of research equipped for such work; but our industries must be alive to what was going on, and they must be capable of adapting the results of such work to themselves when such results were likely to prove advantageous. The domain of improvement of their known metals and the products made from them was really the domain of physical metallurgy, and that was the third field of problems which had been mentioned. It stretched out and thrust its tentacles into every crevice of their iron and steel industries. He believed that, in the future, specification would be, broadly speaking, the furnace in which the results of each one of their industries would be tried, and would be either accepted or be found wanting, and herein lay the possible menace. Specification was the result of science, and specification could only be met with science.

XUM

A South African Foundry Development.

The new foundry erected by the Standard Brass Foundry, Limited, was opened on September 6 by Sir William Hoy, C.M.G., the general manager of South African Railways. The ceremony was attended by representative men from all parts of the Rand. They included Mr. T. Cullinun (chairman of the Transvaal Chamber of Industries); Mr. R. B. Gettliffe (assistant general manager of railways); Mr. G. R. Paterson (general manager



Sir William Hoy (centre), with Mr. F. W. Hobbs (left) and Mr. A. Moore (right), at the Opening Ceremony of the Standard Brass Foundry, Limited, Benoni, S.A.

of Barclays Bank, South Africa); Mr. J. Crossley (Barclays Bank, London); Mr. A. J. Phillips (Messrs. Fraser & Chalmers).

Sir William Hoy congratulated the directors, Mr. A. H. Moore and Mr. F. W. Hobbs, on their enterprise and initiative, and spoke of the importance to South Africa of the undertaking in conjunction with Messrs. J. Stone & Company, Limited, of London, to manufacture much engineering material which was formerly made overseas. He referred appreciatively to the fine laboratory under the charge of Mr. A. K. Gold, who was formerly one of Mr. W. Lambert's assistants in the Deptford works of Messrs. Stone's. The plant is probably the best designed in the Dominion, as intensive study has been devoted to lighting and ventilation. The main bay is 40 ft. wide, and is served by 10-ton three-motor Morris crane. The side bays are 20 ft. × 125 ft. The raw material is brought in bulk to the south side of the plant where a light track is laid running on to an elevator, operated by a Morris electric hoist. Metal is melted by two cupolas lined to 28- and 36-in. dia., placed centrally in one of the side bays. Blast is derived from two direct-coupled motor-driven "Sirocco" blowers suspended beneath the charging platform. All the various units of the sand-mixing plant have their independent motors. The two drying stoves are 20 ft. × 12 ft., and furnished with bogey wagons operated through snatch blocks by the overhead crane. A heavy rail track is laid from the foundry to the fettling yard, where a gantry equipped with a Morris hand-travelling crane serves the grinding and buffing tools and is utilised for loading and for delivery.

The building is a steel and brick structure, having 20 per cent. of its area as windows. All the equipment in the foundry, such as cranes, hoist, ladles, blowers, sand mixers, motors, etc., are of British manufacture. The proprietors insist, however, that, if better deliveries could be made it would greatly facilitate inter-Empire business. The laboratory, which has received the unstinted praise of the local Chemical and Metallurgical Society, was designed and equipped by Mr. Wesley Lambert, of Messrs. J. Stone & Company, and the Standard Brass Foundry is the only engineering firm in South Africa possessing such a department. The many British friends of Mr. Moore and Mr. Hobbs will join us in congratulating them on the progress they have attained, and will wish them every success in their new venture.

The Shipping End of the New Shop, Showing Facilities for Despatching the Finished Castings.

The Raw Materials Arrival Side of the New Buildings.

Open-Hearth Slags.*

By W. C. Hamilton, East Chicago, Ind.

Acid Slags.

Protection is the chief function of an acid slag. The acid process is essentially an oxidising one, but it is not a purifying process, as is the basic.

The bottom of the acid furnace is made up of sand made dense by the addition of slag. The composition of the bath is governed largely by the materials charged and the influence of the flame.

The ordinary charge consists of cold pig and scrap. Iron ore (Fe_2O_3) is used as needed. Slag and sand are charged according to conditions. Oxidation is a necessity in order to eliminate the carbon, manganese and silicon. These elements, together with iron, act as reducing agents under certain conditions. It is therefore possible to have oxidation or reduction in progress in the bath, and the metalloids may exist as a metal or as an oxide.

Silica Additions.

An acid slag consists approximately of 50 per cent. silica and 45 per cent. of iron and manganese oxides, together with other impurities, depending on the composition of the bottom material and the metals charged.

The supply of silicon from the metals is limited, and the metallic oxides or bases formed by oxidation demand more silica than is available from the silicon in the charge, acquiring it from the bottom or from additions of sand.

An excessive oxidation of iron demands an increasing amount of silica. An equilibrium in the composition is closely maintained so far as bases and acids are concerned.

The proper addition of sand will, therefore, prevent silica being absorbed from the bottom. If the bottom is being robbed of silica, damage is done to it, and there is a probability that part of the silica taken from the bottom will be trapped in the bath of metal. One thus may obtain inclusions in the metal with their evil effects on the steel produced.

Slag Added to Bottom.

Slag is added to the bottom of a new furnace in order to make it more dense. Unless this practice is followed, a great deal of molten metal from the first heat will penetrate into the bottom. This iron is gradually oxidised, and will later react with the carbon in the bath. This reaction gives a bottom-boil. Every melter dreads such a boil, as it is a warning of a dangerous condition. In extreme cases this boil may work a hole in the bottom, and the loss of an entire heat from this cause is not a rare occurrence. At best, a boil off the bottom will work impurities upward, which may later be the inclusions which cause a failure of the product. An acid slag is therefore needed as a protection to the bottom. This protection to the bottom in turn protects the metal.

Oxidation in Melting.

When the flame strikes the cold charge, the first action is oxidation. Soon pools of metal begin to form. If about 20 lbs. of slag per ton of charge has been added, a protection for these pools of iron is promptly formed. In addition, good supervision may suggest the use of sand to protect any bare metal in the early stages of melting. This protection is against oxidation and the absorption of sulphur from the flame.

When the bath is completely melted, a slag covering has been formed. This slag is essentially a silicate of iron and manganese. Unless the silicon content of the charge was abnormally high, there is very little of this element in the molten bath. The silicon is oxidised in the melting down process, and goes into the slag formation. The same is true as regards the greater part of the manganese.

The problem for the melter now is to eliminate by oxidation about 0.5 of a per cent. of carbon. At the same time, he must guard against excessive oxidation of the iron in the bath. This oxidation of the carbon may be done partly by using iron ore, but the final stages should be from the influence of the flame, through the slag covering. An extremely bulky and viscous slag does not permit the easy oxidation of carbon. Such a slag will trap the carbon monoxide (CO), and thereby hinder the passage of this gas. When iron ore is used, the temperature of the bath should be quite high, or the gases formed are trapped and the frothy slag is obtained.

Colour of Slag.

The colour of an acid slag, as seen on small pieces broken cold from a test spoon, is of great value in judging the condition of the slag, and thereby the quality of the molten metal. A black slag indicates something is not right. A light-coloured slag is evidence of good quality.

The light-coloured slag can be changed to a black one in a few minutes by carrying a sharp oxidising flame. It is not so easy to change the black slag to a light-coloured one. This change in colour is, no doubt, due to the degree of oxidation of the iron in the slag. Unfortunately, chemical analyses do not give much substantiation to this statement. The total iron oxides are no greater in a black slag.

It is assumed that FeO is the least harmful oxide of iron, and that varying amounts of either Fe_2O_3 or Fe_3O_4 determine the colour of the slag. Possibly the amount of metallic iron has a decided influence. Furthermore, whether the iron oxide exists in a free state or in combination with silica no doubt has a great bearing on the nature of the slag. Chemical or microscopic investigations, so far, have thrown very little light on this subject.

In order to obtain a light-coloured slag, it is the practice very often to add clay (Al_2O_3, $2SiO_2$, $2H_2O$), bauxite (Al_2O_3, $3H_2O$), or limestone ($CaCo_3$), with or without carbon. The alumina (Al_2O_3) in the clay or bauxite or the lime CaO will, as bases, replace a part of the iron oxide in the slag, provided the silica content is not sufficient to absorb the additional bases.

The iron oxide will be released and be thrown back into the bath of metal. Unless reduced, this iron oxide would be carried with the metal as inclusions into the finished products. It would, therefore, be possible to have a light-coloured slag, but with a badly-conditioned bath of metal.

Unless this process of substitution is followed with extreme care, a very poor quality of steel may be produced. Often a melter will add limestone to a slag in order to thin it. If the slag is viscous, due to a high silica content, such an action is logical. However, the ordinary viscous slag is found not to be so on account of composition, but due to physical conditions resulting from some previous error of judgment.

Limestone added to correct this error will not permanently thin the slag. As the iron oxide is eliminated from the slag, the temporary fluidity is lost. It would seem that it is better practice for the ordinary heat to be made without the use of limestone or other substituting bases. Then the melter would depend on the proper control of his flame to obtain the light colour in the slag.

A special practice is to reduce silica from the hearth, and transfer it as silicon to the bath of metal. A slag high in silica is necessary to accomplish this result, and it is good practice to use limestone in order to make such a slag more fluid. No substitution takes place, as an abnormal condition exists, and the lime added will unite with the excess silica.

A slag in an acid furnace is the natural product of the process. Modifications of it, however, are easily made. While the slag is a protection to the bath, it must also act as an agent, transmitting the oxidising action of the flame to the bath of metal.

* Abstracted from a Paper read before the American Foundrymen's Association.

Basic Slags.

The basic bottom is built up with burnt magnesite (magnesium oxide) or burnt dolomite (an oxide of calcium and magnesium). Slag is again necessary to obtain a dense bottom. Lime or limestone is charged in a definite proportion to the charge. From a metallurgical standpoint, limestone ($CaCO_3$) is preferable to lime (CaO) as a flux. However, from an economical view, lime has certain advantages.

Limestone.

Limestone, when charged, must be calcined, which operation requires heat and time in the open-hearth furnace. However, this calcining or elimination of carbon dioxide creates a desirable action in the bath of metal. It has been stated that this ebullition of carbon dioxide aids in the elimination of sulphur. It would appear, however, that this effect is apparent, but not real. Limestone free of sulphur would naturally give a lower sulphur bath than when lime is charged together with its contained sulphur.

The output of a basic open-hearth furnace can be increased about 20 per cent. when lime (CaO) is substituted for limestone ($CaCO_3$).

Amount of Slag Desirable.

The volume of a slag desirable in a basic furnace is an open question. Amounts varying from 8 to 17 per cent. of limestone are considered good practice, depending on requirements and composition of the charge. The lower amounts result in reduction of time and in increased yields.

Table I.—*Analyses of Slags.*

	Heat No. 1 16¾ Per Cent. Limestone ($CaCO_3$)	Heat No. 2 4.3 Per Cent. Lime (CaO) 7.8 Per Cent. Limestone ($CaCO_3$).
	Per cent.	Per cent.
SiO_2	11.00	13.58
FeO	22.90	22.28
MnO	6.46	10.97
CaO	48.87	42.92
MgO	6.75	5.43
P_2O_5	3.85	1.30
S	0.20	0.16
Al_2O_3	—	3.91

The chemical analyses of basic slags, formed by different charges of flux, do not vary greatly so far as the dominating constituents are concerned. The greater use of limestone will, of course, result in the better elimination of phosphorus and sulphur.

An interesting comparison is given in Table I, which shows the effect of different amounts of limestone or lime on the composition of the slag and also on the melting loss in the furnace.

The charges for these two heats were radically different, which fact accounts for certain variations in the composition of the two slags. However, there is practically no difference in the content of iron oxide.

The following data on melting losses is of interest from an economical standpoint:—Heat No. 1 with 16¾ per cent. limestone ($CaCO_3$) had a charge containing 52 per cent. pig-iron; heat No. 2 with 4.3 per cent. lime (CaO) had a charge containing 20 per cent. pig-iron.

Knowing the composition of the charge and by analysing the residual in the bath, it is easy to determine the metalloids lost in the process.

In addition to the metalloids, we must know how much iron is lost in the process.

It is assumed that all of the magnesia in the slag comes from the burnt dolomite used in making up the bottom. Knowing the content of lime and magnesia in this dolomite, it is a matter of proportion to convert the magnesia content of the slag into the amount of lime in the slag which had come from the dolomite.

The theoretical figures of Table II on melting loss have been substantiated by actual weights.

The data of Table II indicate the savings that can be made by a study of the materials charged into a basic open-hearth furnace including the fluxes. Both of these practices are common ones, and show a difference of 4.3 per cent. in the melting losses. It should be noted, however, that coke is used in the No. 2 charge, and it is not included in the metals charged. It has been shown that a low fluxing charge will increase the yield, and a reduction in time is also effected.

Table 2.—*Analysis of Dolomite for Making Bottoms.*

	Per cent. Lime (CaO)	Per cent. Magnesia (MgO)
Heat No 1.	56	40
Heat No. 2	50	30

Heat No. 1—6.75 per cent. magnesia $\times \frac{56}{40}$ = 9.45 per cent. lime from bottom

Heat No. 2—5.43 per cent. magnesia $\times \frac{50}{30}$ = 9.05 per cent. lime from bottom

	Heat No. 1	Heat No. 2
Lime in slag (CaO) ..	48.87 per cent.	42.99 per cent.
Lime from bottom ..	9.45 per cent.	9.05 per cent.
Lime from charge ..	39.42 per cent.	33.94 per cent.
Lime (CaO) charged ..	4,666 lbs.	2,180 lbs.
100 per cent. or weight of slag	11,827 lbs.	6,423 lbs.
Iron oxide as FeO ..	39.42 per cent. or 2,710 lbs.	22.28 per cent. or 1,431 lbs.
Iron in slag	2,100 lbs.	1,109 lbs.
Total metals charged, cold	53,520 lbs.	52,090 lbs.
Iron in slag ..	3.9 per cent.	2.1 per cent.
Metalloids lost ..	5.8 per cent.	3.3 per cent.
Iron in slag	3.9 per cent.	2.1 per cent.
Melting loss ..	9.7 per cent.	5.4 per cent.

Amount of Lime in Charge.

The amount of lime necessary will depend to a great extent on the amount of impurities in the charge. Sand adhering to castings charged will require extra lime. A well-established practice is to add burnt lime during the refining period as it is needed to condition the slag.

Iron Oxide in Slag.

The iron oxide in the basic slag, as in the acid slag, is the factor having the greatest influence on the quality of the steel. On account of other strong bases present, it is assumed that iron and manganese oxides in the basic slags may exist as either bases or acids. Granting this assumption, it is readily seen a basic slag may have its character changed at frequent intervals.

Unfortunately, the colour of the cold basic slag is always very dark, and gives no indication of the character of the slag. The basic melter must depend upon his skill in judging the slag as it exists in a molten state. Ordinarily, he is governed mostly by the consistency of the slag.

Lime will always make the slag more thick. Iron ore promotes fluidity, but its addition is limited by the carbon content of the bath and its temperature.

Use of Fluor Spar.

The use of fluor spar (calcium fluoride) to confer fluidity to a basic slag is a common practice. It is well known that an addition of 50 lbs. of fluor spar to a basic slag weighing 10,000 lbs. will have a marked influence on the fluidity of the slag.

What reaction takes place has been considered by the writer for many years, and some time ago a catalytic theory was advanced. This theory is best illustrated by the following equations:—

$$(I)\ 3SiO_2 + 2CaF_2 = SiF_4 + 2CaSiO_3.$$

$$(II)\ 3CaO + SiF_4 = 2CaF_2 + CaSiO_3.$$

In reaction No. 1, the fluor spar reacts with silica, giving calcium silicate and silicon fluoride, a gas. A part of the silicon fluoride gas will no doubt escape. However, it is assumed that the greater part of it will react with lime as shown in equation No. II. This reaction gives more calcium silicate and produces calcium fluoride, which would again take part in reaction No. 1, thus completing a cycle.

Calcium silicate, a fusible slag, has been formed, and the fluor spar is simply an agent to produce this slag. Such an action would account for the very small amount of fluor spar which is necessary to change the consistency of a large mass of slag in the stage of formation.

Inclusions.

While the basic reactions are quite different from the acid, nevertheless both are a process of oxidation. The problem in either case is to oxidise the constituents without having an excessive oxidation of the iron.

A combination of slag and steel in the finished product is fatal. Fortunately, slag is much lighter than iron, and there is a natural separation of the two materials in a molten condition. Too often, however, small globules of slag are trapped in the molten metal.

One of the great problems in the steel industry is to produce a product free of inclusions, and these inclusions are to a great extent particles of slag. Steel makers to-day realise the importance of slag in relation to the production of good steel.

Hot Top for Ingot Moulds.

The introduction of a pouring device for improving the yield in the production of steel ingots and minimising the risk of blow-holes and piping, is noted in an article* by Mr. John D. Knox. Mr. Knox describes a form of ingot-mould top which appears to have met with practical success and to be extremely simple in design.

In the ordinary method of pouring it is obvious that with a ladle containing perhaps 100 tons of metal and with the use of a nozzle of anything from ½-in. to 3-in. diameter, there must be considerable head pressure on the stream of molten metal pouring into the mould. This pressure causes the stream to force itself to a considerable depth in the mould, with the result that slag and impurities which might come to the surface are forced down again into the metal. The same applies to the gases which, in the form of blow-holes, are forced deeper into the metal, sometimes too deeply to again rise to the surface.

The form of mould top designed to overcome these difficulties is shown in the annexed cuts, illustrating respectively an open-top and closed-top mould. It consists of a reservoir and a float made of good firebrick material. The reservoir rests on the top inside edge of the mould as shown, though it may be placed as far down the mould as desired. The float rests on top of the reservoir and can be lowered into it to any desired depth. The bottom of each float has four or more holes located as far from the centre as possible. The diameter of the openings varies according to the grade of steel being poured, the size of the ladle nozzle, the size of the heat being poured, and the shape of the ladle. Floats now in use at various steelworks usually are provided with 2-in. openings, one in each corner. One object of the reservoir and float is to secure a large yield of steel from each open-hearth heat and to improve the surface so that chipping is reduced to the minimum. As a result, the net production is increased without increasing the investment of plant equipment. Metal is poured from the ladle into the float and then drains through the holes in the float into the mould proper. The heavy head pressure is thus confined to the float, the metal flowing through the holes without any penetrating effect upon the metal as it rises in the mould. The apertures in the float are provided at points off the centre of the mould so that the stream, draining down, allows the centre of the ingot or metal, which is the hottest part, to freely discharge gases or air, and thus form a more solid and compact ingot. The elimination of the heavy head pressure prevents blow-holes in the form of trapped gases from being forced down into the metal of the mould proper.

During the process of pouring, the walls of the float and reservoir become heated to such a high degree that the metal which is last poured loses none of its original heat through contact with the walls of the float and reservoir. When the stream is shut off in the ladle, the float, which is lighter than the metal, rises to the top of the reservoir. The float and reservoir, which have become highly heated during the pouring of the steel, will retain the heat on the top or upper portion of the ingot for a much longer period than has so far been obtained, without the use of any expensive fuels or gases.

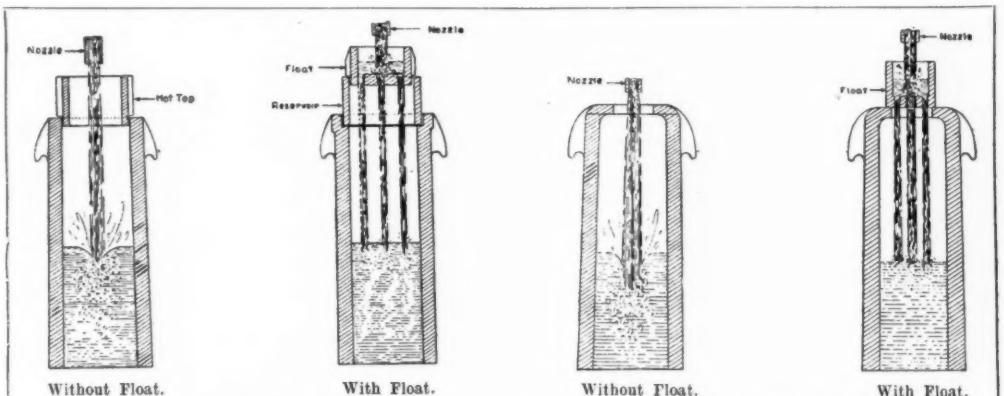


Fig. 1.—Open-Top Mould. Fig. 2.—Closed-Top Mould.

Sections illustrating Pouring Effect when using Ingot Moulds with and without Floats.

* "The Iron Trade Review."

Book Review.

A Supplement to Catalogue of British Scientific and Technical Books. Arranged by Daphne Shaw. Published by the British Science Guild, 6, John Street, Adelphi, London, W.C.2. Price 2s. 6d. net.

We never had a high opinion of this particular catalogue, and the publication of a Supplement does not remedy what we consider to be inherent faults.

Mining engineers do not wish to overload the bookcases with a catalogue of books on Anatomy and Physiology, nor do foundrymen frequently have to consult works on Anthropology or Zoology. We repeat the advice we have previously tendered, that a series of overlapping pamphlets would fill a real want. Thus, for foundrymen, the pamphlet would contain details of the works published on such kindred subjects as metallurgy and geology. This last named subject would appear also in a section prepared for mining engineers. Actually, works on foundry practice are classified with "Metallurgy: Mining." This Supplement has stiff grey paper backs, and contains 9,515 references to British books. We consider the alphabetical arrangement used in the Supplement somewhat poorer than that adopted in the main volume, in which related subjects were grouped together.

Watsons (Metallurgists), Limited, have secured an order, and are shipping this month a one-ton Greaves Etchells furnace, for electric melting for castings work, to the Hongkong and Whampoa Docks, Hongkong.

XUM

Heat and Scale Resisting Cast Irons.

By Oliver Smalley, New York City.

(*Continued from page 305.*)

PART II.—CHILLING IRONS.

Where the combined properties of both white and grey irons are required in the same casting, cast iron becomes possibly the most complex and least understood of any metallurgical product. No fundamental advances can as yet be claimed, and any progress in the development of superior grey irons for high duty purposes finds little application to either the car wheel or chill roll.

Chilled Car Wheels.

The ability of the cast-iron car wheel to withstand severe sudden changes of temperature in service is second only in importance to a hard-wearing surface. Due to the complexity of the mould into which it is poured, casting strains are encountered in the car wheel, which render it unsuitable for service. By putting the wheels in soaking pits at approximately 895 deg. C. after casting, these strains are somewhat relieved or removed.

To determine the efficacy of this annealing process and the ability of the iron to withstand severe changes of temperature in service, the "thermal test" is applied. This test is made by pouring a ring of molten iron around the chill tread of the wheel. The severity of the test varies with different railway companies' specifications, but commonly if a wheel is found broken in pieces, or if any cracks in the plate extend through or into the rim after pouring a 2-in. section of metal around the wheel, in 2 min. or under, all wheels of the same tap as the wheel under test are rejected.

The more highly strained the wheel after soaking, the sooner does cracking occur on test, hence any condition conducive to a good thermal test without affecting the service life of the wheel is desirable.

The variation in composition of 1,040 wheels that have given average service or better is:—TC, 3.0 to 4.10; Si, 0.43 to 0.95; Mn, 0.30 to 0.92; P, 0.182 to 0.480; and S, 0.092 to 0.230 per cent.

The average chemical analysis of these wheels is:—C, 0.30; Gr, 2.82; TC, 3.42; Si, 0.63; Mn, 0.54; P, 0.319; and S, 0.151 per cent.

In a highly competitive field, the car-wheel maker aims to meet both the physical and chemical specifications of the railway by the use of as little pig-iron as possible, melting with as low a coke ratio as will bring his metal down and by driving the cupola to maximum capacity.

The average metal mixtures comprise 80 to 100 per cent. old wheels, 0 to 20 per cent. pig-iron, 9 to 10 per cent. steel. For the manufacture of superior wheels, where severe service conditions have to be met, special mixtures are used, including the use of larger quantities of pig-iron or pig-iron of superior quality or even charcoal pig-iron. This latter is favoured where extra severe thermal test is enforced.

Table III.—*Details of Four Tested Car Wheels.*

Wheel.	C.C.	G.C.	T.C.	Si.	Mn.	P.	S.	Fracture.	Comments.
1	0.28	3.33	3.61	0.69	0.81	0.286	0.110	Black Grey	Withstood severe thermal test. Returned from service. Chill worn thin.
2	0.40	3.13	3.53	0.73	0.53	0.273	0.142	Dark Grey	Withstood standard thermal test. Returned from service. Chill worn thin.
3	0.66	2.84	3.50	0.66	0.86	0.361	0.138	Light Grey	Passed thermal test unsatisfactorily. Cracked in 2 mins. 5 secs. with loud report.
4	0.68	2.78	3.46	0.69	0.90	0.374	0.178	Light Grey Sparkle	Failed thermal test. Cracked in 1 min. 5 secs. with exceptionally loud report.

Variations of chill are corrected in the ladle, by the addition of steel or ferro-silicon. If the metal is on the soft side, steel scrap is used, and ferro-silicon when the chill is high. Some car-wheel makers introduce small additions of crushed ferro-manganese to each car-wheel ladle. Whether this is to correct an oxidised condition of the steel, to facilitate machining or to increase solidity, the car-wheel maker is not certain. The common contention is that it exerts an all-round beneficial effect. Why charcoal or superior pig-iron should enable a wheel to withstand a severer thermal test, and why the all-scrap wheel made under similar conditions should be stronger, have a closer grain, and present a lighter-coloured fracture, but fail more readily under thermal test, is also a matter for conjecture.

Fig. 2.—Photomicrograph of Special Wheel No. 1 × 200.

In Table III details of four wheels offering exceptional contrast are given. Wheel No. 1 was made to meet an extraordinarily severe thermal test. This wheel was returned after several years of service. On breaking, it presented a dark grey fracture; wheel No. 4, made in the ordinary way, failed badly on thermal test and presented a light grey sparkling fracture on breaking.

The chemical analyses show:—

(1) That the total carbon and graphite contents are the highest and the combined carbon and sulphur contents lowest in the special wheel.

(2) That the total carbon and graphite contents are lowest and the combined carbon and sulphur

contents highest in the wheel that failed quickest under thermal test.

(3) That there is nothing in the chemical composition of wheel No. 3 to explain its low thermal test.

Physical Examination.

Structurally, car-wheel iron may be compared with ordinary carbon tool steel. The essential difference is that a car wheel, except at the tread, is interlaced by tiny flakes of graphite which occupy approximately 7 per cent. of the total volume. Thus, rapidly-cooled car-wheel iron presents the same susceptibility to spontaneous cracking on sudden heating as hardened tool steel, while well-annealed iron may be subjected to the severe thermal stress without any risk of cracking.

Because the crystal formation of pearlite is a true indication of the efficacy or otherwise of an annealing process, and because its formation can be readily ascertained, we have at our disposal a simple means not only to measure and control the annealing process, and because its formation can in what way the nature of any combination of irons differ from any other combination, and the effect of different cupola conditions on any particular mixture. In other words, a simple metallographic examination offers a direct means to control soaking-pit practice scientifically, and also to understand and follow the physical changes that accompany any new set of conditions, whether metallurgical or foundry.

One other essential difference between the microstructure of tool steel and car-wheel iron is the presence of phosphide of iron eutectoid, which occupies about 3 per cent. of the whole volume of the iron. Exerting an embrittling effect on cast iron, it renders car wheel more susceptible to cracking under thermal test.

Photomicrographs of Car-Wheel Irons.

The photomicrographs of Figs. 2 to 5 portray the microstructure of each wheel at a magnification of 200 times. Special wheel No. 1 (Fig. 2), displays a matrix of well-marked laminated pearlite, small quantities of phosphide eutectoid uniformly distributed, and graphite flakes, long, thin and intermingling.

Fig. 3.—Photomicrograph of Normal Wheel × 200.

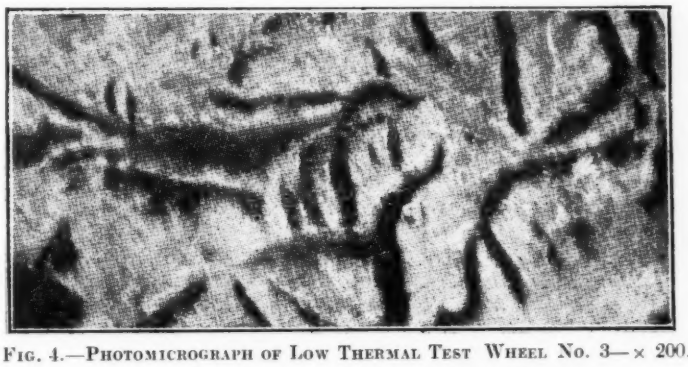


Fig. 4.—Photomicrograph of Low Thermal Test Wheel No. 3—× 200.

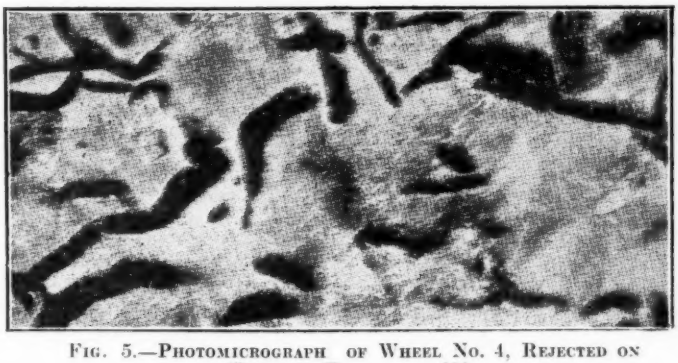


Fig. 5.—Photomicrograph of Wheel No. 4, Rejected on Thermal Test — × 200.

This structure is common to that of soft grey irons designed to withstand sudden changes of temperature without cracking. It is, however, the converse of what is desired in a tough, dense, hard-wearing iron.

Normal wheel No. 2 (Fig. 3), reveals a matrix of laminated pearlite that does not display so marked a separation of the carbide and ferrite as special wheel No. 1. The laminations, however, are sufficiently well marked as to indicate complete annealing after casting; the form of the graphite flakes is similar to wheel No. 1 except that they are not so long and continuous or present in such large quantities.

The photomicrograph of wheel No. 3 (low thermal test) is shown in Fig. 4. The carbide matrix is sorbitic. Pearlitic formation can be traced, but the quantity present is infinitely small. Another structural difference displayed by this

wheel is the short, stubby, inclined to be curly, form of the graphite.

The photomicrograph of wheel No. 4 (rejected on thermal test), displayed in Fig. 5, shows structural features common to those of wheel No. 3. The carbide is a little more pearlitic, though the majority is distinctly sorbitic, while the graphite has the same stubby form.

These four illustrations, suitably chosen from a number in an endeavour to correlate the structural disposition of the micro-constituents and the physical properties, explain the superior thermal properties of wheels Nos. 1 and 2; show the reason of the dark grey fracture presented by wheels Nos. 1 and 2, and of the cause of the light grey sparkling fractures of wheels Nos. 3 and 4; and explain the superiority of wheels Nos. 3 and 4 under the drop test. Incidentally they lightly touch on the vexed problem of the difference between hot- and cold-blast pig-irons; the relation of fracture to chemical composition; the difference between cast iron and semi-steel; and finally throw light on the anticipated comparative behaviour of high-duty irons made from high-grade, pig-rich mixtures and those made from low-grade white iron and graphitised when subjected to rapid heating and cooling in service.

The explanation offered for the superiority of special wheel No. 1 under thermal tests is that not only was the chemical composition such as to permit a freer deposition of graphite and a free separation of the carbide eutectoid (pearlite) into its component parts cementite and ferrite, but that because of the greater purity of the irons used (rich pig mix) and melting in the first few charges, there was less oxygenation and gaseous contamination than obtained in wheel No. 4, for example, which was cast from the last few tons of a melt (scrap and steel) of over 220 tons, when the cupola was emitting deep brown oxide fumes from the stack.

(To be continued.)

Interlocking Tiles for Furnace Roofs.

An interlocking furnace roof tile has been designed and patented in the United States. As will be seen from the accompanying illustrations, interlocking is accomplished by the use of a triangular tongue on one face, and groove on the opposite face of each tile. The triangle of the tongue and groove has its base on the inner, high-temperature face of the tile and its apex toward the top of the tile. The thickness or offset of the tongue is about ¼ in. and the depth of the groove corresponds. The tongue and groove extend in height about three-quarters of the tile length.

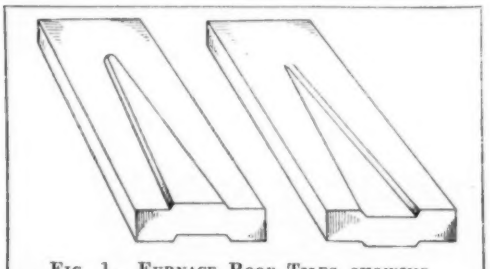


FIG. 1.—FURNACE ROOF TILES SHOWING TONGUE AND GROOVE.

This leaves the remainder of the tile face flat and smooth for carrying the ring or roof load when making suitable allowance for expansion on the inner tile ends. Broken pieces, if of appreciable size, do not slip free or fall out, being prevented from slipping out sideways by the adjacent rings on either side. The groove side cannot slip off the tongue and drop out, as the ring load will cause the tiles to inter-engage. Thus the glazed end, regardless of its broken condition, will continue to serve its refractory purpose.

In a preliminary roof test, the service behaviour of the tongue-and-groove tile was compared with that of the conventional smooth tile roof. A fairly representative section of roof was installed using the interlocking tiles. The number of days of service was the usual run, determined by the holes and weak sections in the plain roof. The interlocking section was still good for considerably more service when dismantled along with the smooth tile roof. Inspection made of this test roof showed that several tongue-and-groove tiles had slipped out ½ in. or more, but had been held in this position throughout the run. In designing the interlocking tile, a clearance between the tongue and groove was provided to insure ease of installation and self-adjusting of the ring. The broken ends, therefore, slipped down enough to take up this clearance, and in this position the glazed end was held in place, keeping the surface of the roof smooth and regular.

In charging, some scrap was forced up into the interlocking roof section, pushing several tiles out of position. These tiles immediately settled back into proper alignment and stood up throughout the run. The furnace during this test was cooled down and again reheated. The interlocking section of the roof did not lose a broken tile end nor show any injurious results from the changes in temperature. The plain roof section, however, showed the usual dropping out of tiles.

To restrict dropping out of tile ends, it is necessary to key a smooth tile roof tightly. When a roof so keyed is brought up to working temperatures, the inner hot tile ends will expand fully and

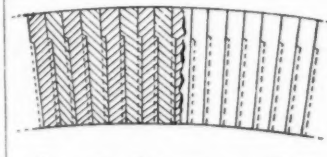


FIG. 2.—SECTION OF ROOF MADE WITH INTERLOCKING TILES.

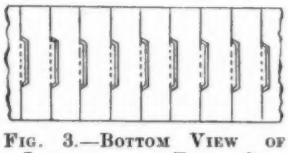


FIG. 3.—BOTTOM VIEW OF INTERLOCKING TILE CONSTRUCTION SHOWING CLEARANCE.

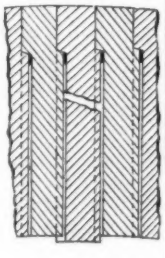


FIG. 4.—SHOWING BROKEN TILE, PREVENTED FROM FALLING BY TONGUE AND GROOVE.

the outer tile ends less. A great part of the expansion in silica brick takes place between 150 and 425 deg. C. This expansion ranges from ⅛ in. to ¼ in. per linear ft. The whole ring or roof load is concentrated on the inner hot tile section, for, as the ring rises, the outer cold tile ends are spread well apart, with no bearing contact. This excessive pinching and squeezing load is too great for safety with hot silica shapes, and sooner or later the internal structure of this exposed furnace surface is crushed and broken, reducing its resistance to flame and gas erosion.

A suspended open-hearth roof test recently made in Ohio showed that, by reducing this item of excessive ring load within a safe margin for hot silica shapes, the roof life could be nearly doubled. When using the interlocking tile roof, says "The Iron Age," suitable expansion space can be allowed on the inner tile ends. In this way the ring load can be caused to centre and remain on the outer rigid cold tile ends, thus reducing the load on the semi-soft inner tile ends. This expansion allowance can be secured by using a larger number of suitable wedge shapes. Between the inner tile ends at definite intervals a strip of cardboard can be inserted when installing this roof, properly gauging this allowance.

First Locomotive Built in Rumania.—The Reshitza Works have recently placed in service the first locomotive built entirely in Rumania.

German Floating Exhibition.—An exhibition of the products of German handicraft and industry left Bremen recently on a world tour on board the four-masted schooner "Vaterland," which will visit North America, South America, Africa, Australia, the South Sea Islands, India, China, and Japan. The venture is being supported by prominent industrial firms like Krupps, Mannheim motor works, Henschel's locomotive works and other concerns.

Telegrams: "THROWER, GLASGOW." Telephone: 5909 CENTRAL.

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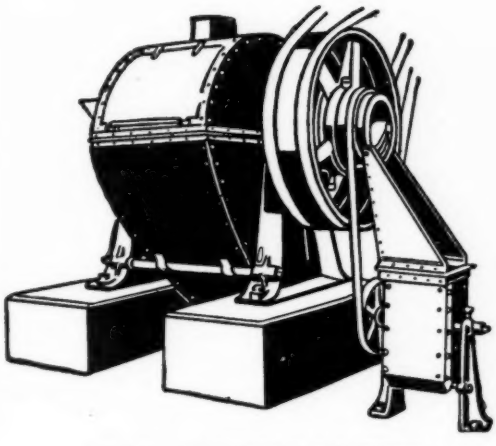

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BRASS RECOVERY MACHINES

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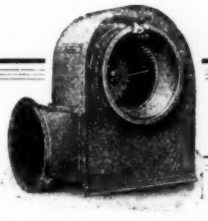

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Trade Talk.

The Mannesmann Tube Works, Landore, Swansea, restarted last Monday.

Leyland Motors, Limited, have established a branch at Dunbar Street, Belfast.

Manning, Wardle & Company, Limited, Hunslet, Leeds, have decided to close their works temporarily until trade revives.

The Etna Iron and Steel Company, Limited, have removed their London offices to 82/3, Fenchurch Street, London, E.C.3.

The Becco Engineering and Chemical Company, Limited, have removed to Fitzalan House, Arundel Street, Strand, W.C.2.

Hadfields, Limited, owing to the restriction of the supply of Continental fuel, had to close down last week.

Sheffield Steel Products, Limited, have removed their London office to Stevenage House, 40/44, Holborn Viaduct, London, E.C.1.

George Cohen, Sons & Company, Limited, have opened a large showroom for machine tools at Willesden Lane, Park Royal, London, N.W.10.

Dr. Robert J. Anderson has changed his address from P. O., Box 10, Stock Yards Station, Cincinnati, Ohio, to 1658 Woodward Ave., Lakewood, Cleveland, Ohio.

T. F. Jemmett & Company, iron, steel and metal merchants, have removed from 67, Broad Street Avenue, London, E.C.2, to 82/3, Fenchurch Street, London, E.C.3.

The Pont-a-Mousson Cast Iron Pipe Foundries have secured a contract for the State of Sao Paulo for the supply of 21,000 tons of cast-iron segments and cast-iron water pipes.

Pneulec, Limited, have received an order from the Sinclair Iron Company, Limited, Ketley, Salop, for two cupolas, each 6 ft. 6 in. dia. shell, complete with "B" type special spark arresters, two fans, fan pipes, two electric hoists and staging.

The grinding and pulverising offices of International Combustion, Limited, 11, Southampton Row, London, W.C.1, report the sale of five Raymond mills and pulverisers for England, Spain and France.

An order for 30 open wagons, 10 bogie brake vans, and 20 bogie tank wagons for the Sudan Government Railway has been placed with the Blake Boiler, Wagon & Engineering Company, Limited, Darlington.

The Stanton Ironworks Company, Limited, are reported to have placed orders with Head, Wrightson & Company, Limited, of Thornaby-on-Tees, for three blast furnaces, together with the necessary auxiliaries.

Richter & Pickis, 101, Finsbury Pavement, London, E.C.2, have been appointed British agents for Stahlunion Export G.m.b.H., Düsseldorf, for hot rolled mild steel strip, tube strip and universal strip.

Mr. F. H. Shaw, hitherto with S. W. Carlton & Company, iron, tinplate, etc., merchants, 32, Lime Street, E.C.3, has joined the staff of William Jacks & Company, Winchester House, Old Broad Street, London, E.C.2.

A. Hall & Company, Limited, shipbuilders and engineers, Footdee, Aberdeen, have secured orders for the construction of two non-propelled hopper barges and a sea-going tug for the Tilbury Contracting and Dredging Company, Limited, London.

The African Iron & Steel Products, Limited, have recently been reconstructed with a larger capital, and are now known as the African Iron and Steel Products (1926), Limited. The company report that the demand for materials is, if anything, larger than it has been for some months past.

James Gordon & Company, Limited, Windsor House, Kingsway, London, W.C.2, have received an order from an industrial concern for 46 duplex Mono combustion recorders. This instrument records both CO_2 and CO on one chart. It is believed this constitutes a record order in this country for combustion recorders.

Of the six Silver liners ordered from Wear builders at the beginning of the year, only two have been launched and work on the other four is held up. Sir James Laing & Sons, Limited, have an order in hand for an oil tanker which the British Oil Tanker Company ordered in March last, and recently they obtained an order from the Burma Oil Company for an oil carrier of 8,000 tons, the engines of which will be made by George Clark, Limited, Sunderland.

Wingrove & Rogers, Limited, Mill Lane, Old Swan, Liverpool, have recently acquired the business of British Electric Vehicles, Limited, Southport. The firm have been manufacturing controllers under their own patents for British Electric Vehicles, Limited, since 1919, and they will now manufacture complete all standard designs of B.E.V. trucks and locos in their Liverpool factory. The present management and the technical staff of British Electric Vehicles, Limited, are being retained so that continuity of design will be secured. A London office has been opened at 63, Queen Victoria Street, E.C.4, under the charge of Major G. D. Ozanne and Mr. N. E. Bayliff. Application has been made to the Board of Trade to amalgamate the two names in the form Wingrove and Rogers British Electric Vehicles, Limited.

The directors of the British Schurmann Cupola and Foundry Equipment Company, Limited, of 15, Victoria Street, Westminster, London, S.W.1, desire to notify their many friends that they have decided to close down the company forthwith. The British agencies previously held by the company with Messrs. Alfred Gutmann, of Altona, Hamburg, for semi-blast apparatus, and with Messrs. Ferdinand Steinert, of Coln-Bickendorf, Germany, for the sale of magnetic separators, have been cancelled, and we are given to understand that arrangements have been made between the above companies and Messrs. T. Fearnley Allen & Sons, of 51, Norwich Union Chambers, Congreve Street, Birmingham, to take up the exploitation of their plants in this country. All business relating to the Schürmann Regenerative Cupola will in future be dealt with by the Schurmann-Ofen Company, of Industriehaus, Am Wehrhahn, Düsseldorf, Germany.

Obituary.

Mr. J. Tildesley, J.P., of Westfield, Willenhall, who died recently at the age of 88, retired some years ago from the business of L. Tildesley & Company, general and malleable ironfounders, etc., Cross Street, Willenhall.

Mr. R. A. Wolff, senior partner of Rudolf Wolff & Company, 36, Lime Street, London, E.C.3, died on September 29 at his residence in Folkestone. Owing to serious and protracted illness, the deceased gentleman had been unable to take any active part in the business for the past four years. No change will, therefore, be involved in the conduct of the business, which will be carried on by the remaining partners as hitherto.

Contracts Open.

Newton Abbot.—10 tons of 6-in. and about 10 tons of 9-in. new or second-hand cast-iron pipes, for the Newton Abbot Rural District Council. Mr. S. Olver, highway surveyor, 9, Marlborough Terrace, Bovey Tracey.

Pretoria, October 19.—Cast-iron pipe fittings and valves (Contract No. 176), for the Municipality of Pretoria. The Department of Overseas Trade, 35, Old Queen Street, London, S.W.1. (Ref. A.X. 3,641.)

Blackrock, Ireland, October 26.—Supplying and fixing electrically-driven pumping plant, for the Blackrock and Kingstown Drainage Board. Messrs. Kaye Parry, Ross and Hendy, engineers, 48, Kildare Street, Dublin. (Bond with two sureties required.)

New Companies.

Clyde Heat Treatment Company, Limited, 100, Clarence Street, Glasgow.—Capital £1,000 in £1 shares.

Stroud Metal & Plating Company, Limited, Dudbridge Mills, Stroud, Glos.—Capital £5,000 in £1 shares.

Thomas Francis & Company, Limited.—Capital £10,000 in £1 shares, to acquire business of Thomas Francis & Company, Limited (incorporated in 1888), manufacturers of malleable iron nails and castings, etc.

Welwyn Foundry Company, Limited, 10, Church Street, Chelsea, S.W.3.—Capital £10,000 in £1 shares. Directors: Mrs. Mary Muirhead, Abbotshaugh, Falkirk, Scotland; Mrs. Isabella F. Aitken, 72, Branstone Road, Burton-on-Trent; C. G. Fraser, Deeside, Burdon Road, Cheam, Surrey; V. E. Ellis, 90, Mount Nod Road, Streatham, S.W.16.

British Trade Corporation, Limited, 13-14, Austin Friars, E.C.—Capital £1,000,000 in 500,000 "A" shares of £1 each and 200,000 ordinary shares of £2 10s. each. Directors: Baron Faringdon, 18, Arlington Street, S.W.1; Sir Arthur Balfour, Arcadia, Sheffield (chairman and managing director of Arthur Balfour & Company, Limited); Major Julian Day, 26, Pont Street, S.W.1; Arthur G. M. Dickson, 10, St. John's Wood Park, N.W.8; Sir Harry Goschen, Durrington House, Harlow; Lennox B. Lee, J.P., How Caple Court, near Ross, Herefordshire; Sir John H. B. Noble, Bt., Ardkinglass, Inveraray, N.B.; Robert G. Perry, Barton House, Moreton-in-Marsh, Glos. (chairman of Chemical Manufacturers' Association); Sir William B. Plat, Wykham Rise, Totteridge, Herts; and Sir Harold E. Snagge, Sandhills, Bletchingley, Surrey. Secretary: George Brownlie.

"SERVICE GRC FIRST"

TO-DAY

MORE THAN EVER BEFORE

NATIONAL INTERESTS and NATIONAL SELF-PRESERVATION DEMAND the development of national resources in every possible shape or form, and the retention of British money at home.

BUY
BRITISH STEEL CASTINGS
AND
BRITISH STEEL FOUNDRY
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THE GENERAL REFRACTORIES CO., Ltd.
Sheffield,

the sole makers of the celebrated

"YORKSHIRE SAND"

for Steel Founders, are prepared to meet all competition from either home or abroad—in quality, delivery, price, convenience or economy, and will welcome requests for further details.

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No need to try and remember our name in case it is unfamiliar to you. This is our British Monomark. Envelopes addressed simply thus will be delivered to us by arrangement with the G.P.O.

IRON AND STEEL MARKETS.

Pig-Iron.

MIDDLESBROUGH.—With practically the entire blast-furnace plant on the North-East Coast non-productive for the time being, the market for Cleveland foundry pig is necessarily suspended as far as the actual business of buying and selling is concerned, while interest in forward transactions can only be regarded from a purely speculative point of view. The position is now entirely dependent upon a final decision as to the future cost of fuel, which must at present remain purely a matter for conjecture, upon which it is impossible to base anything like a reliable conclusion. It is, however, to be feared that very slight hopes can be entertained of any lowering of prices in the immediate future, as it must necessarily be some considerable time before the production of pig-iron can return to normal levels. Current market opinion, as regards foundry iron, is now to the effect that there will be none to be had before the latter part of October, and for this makers are demanding no less than 117s. 6d. per ton for the No. 3 quality. Other brands are all but unobtainable, and the nominal prices are:—No. 1, 120s.; No. 4 foundry, 116s. 6d.; and No. 4 forge, 116s. per ton.

Supplies of hematite on Tees-side are extremely restricted, and quotations are irregular. Mixed numbers are offering at about 87s. 6d. per ton. There are still a few very small parcels obtainable in second hands. On the North-West Coast, Bessemer mixed numbers are still quoted at £4 4s. c.i.f. Welsh ports, £4 8s. 6d. per ton delivered at Glasgow, £4 15s. per ton delivered at Sheffield, and £5 7s. 6d. to £5 10s. per ton delivered at Birmingham.

LANCASHIRE.—With the exception of a very limited stock held by merchants, there is now an actual famine in the local markets for foundry pig, and exceptionally high prices are the rule.

Metals.

Copper.—Recent decreased consumptive demand in home industries has had the anticipated effect upon the market for standard copper, and prices last week evidenced a further weakening in current values. Developments in the statistical position have been in line with expectations, home stocks in official warehouses having been reduced to 39,029 tons. Of this refined metal amounted to only 2,683 tons. Further good quantities of rough are believed to be going abroad, and by the end of the year stocks may be reduced to approximately 30,000 tons, which would indicate a decrease of roughly 25,000 tons on the year.

Official closing prices of standard copper have been as follow:—

Cash: Thursday, £57 10s. to £57 12s. 6d.; Friday, £57 7s. 6d. to £57 10s.; Monday, £57 12s. 6d. to £57 15s.; Tuesday, £58 to £58 2s. 6d.; Wednesday, £58 17s. 6d. to £59.

Three Months: Thursday, £58 7s. 6d. to £58 10s.; Friday, £58 2s. 6d. to £58 5s.; Monday, £58 7s. 6d. to £58 10s.; Tuesday, £58 17s. 6d. to £59; Wednesday, £59 15s. to £59 17s. 5d.

Tin.—The unexpected disclosure of a slight increase in the visible supplies of tin in the official figures for September, issued last week, had a disturbing effect upon markets, although the depression was only temporary, and was quickly followed by a reaction to higher levels. A summary of the monthly returns shows an increase of supplies from 8,581 tons to 9,791 tons, and the increase in the Straits shipments with smaller deliveries to the U.K. explain the slightly larger stocks. Deliveries nevertheless amounted to 9,093 tons, against 8,997 tons for August. The sharp rise in the price of the metal indicates that there is no vital change in the position, and the statistical position is still strong.

Official closing prices of standard tin have been as under:—

Cash: Thursday, £318 10s. to £318 15s.; Friday, £315 5s. to £315 10s.; Monday, £315 to £315 10s.; Tuesday, £312 5s. to £312 10s.; Wednesday, £312 5s. to £312 15s.

Three Months: Thursday, £306 15s. to £307; Friday, £303 10s. to £303 15s.; Monday, £303 12s. 6d. to £303 17s. 6d.; Tuesday, £301 15s. to £302; Wednesday, £301 15s. to £302 5s.

Spelter.—With regard to this metal, according to a trade circular, reports from the Continent would seem to indicate a slight improvement there, with the possibility of renewed buying in the near future. The market in America is reported as quietly firm, and as consumption there is maintained at a very high level, there would seem to be little weakness to apprehend in this direction.

The following are the week's prices:—

Ordinary: Thursday, £34; Friday, £33 18s. 9d.; Monday, £34 3s. 9d.; Tuesday, £34 2s. 6d.; Wednesday, £34 3s. 9d.

Lead.—The market for soft foreign pig continues quiet, while demand on the part of home consumers remains very dull, as also does business on the Continent, where inquiry has been particularly slack. No doubt the approaching winter and the probable consequent relaxation in demand for building purposes has occasioned buyers to adopt a rather reserved attitude.

The week's prices are appended:—

Soft foreign (prompt): Thursday, £31; Friday, £30 10s.; Monday, £30 12s. 6d.; Tuesday, £30 11s. 3d.; Wednesday, £30 15s.

FOUNDRY BRUSHES OF QUALITY—USED ALL OVER THE WORLD

SIEVES

RIDDLES

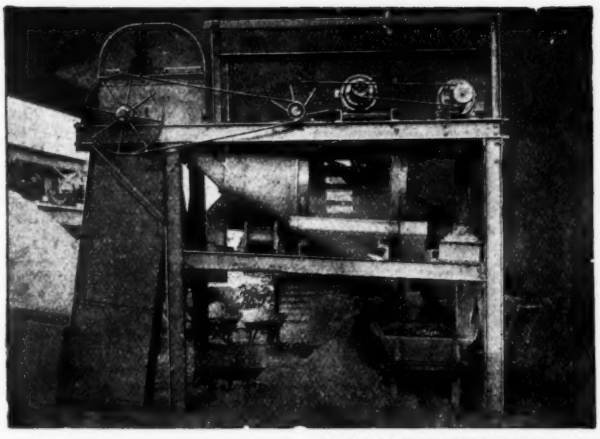
BEST MATERIAL—WELL FILLED—QUICK DELIVERY, AND AT THE RIGHT PRICES.

BETHEL RHODES & SONS, WIREWORKS, NORTH ST., KEIGHLEY, YORKS. ESTABLISHED 1835. SEND FOR LIST.

Ground Ganister,
Steel Moulders' Composition,
Silica Bricks, Refractory Goods.

PICKFORD, HOLLAND & Co., Ld., SHEFFIELD.

A REVELATION TO IRONFOUNDERS



The "RAPID" Patent Self-Contained Combined Sand Sifter and Electro Magnetic Separator Equipment.

TYPES AND SIZES TO SUIT ALL FOUNDRY REQUIREMENTS.

Practically no Iron Losses.

It Saves as it Sieves as it Separates.

Recovers Brads, Splashings, Fettlings, Gits and the Like.

LET YOUR PROBLEMS BE OUR PLEASURE.

THE RAPID MAGNETTING MACHINE CO., LTD., LOMBARD ST., B'HAM.

Regd. Design No. 718381

PROVED THEIR WORTH!

DEAR SIR, BRAINTREE

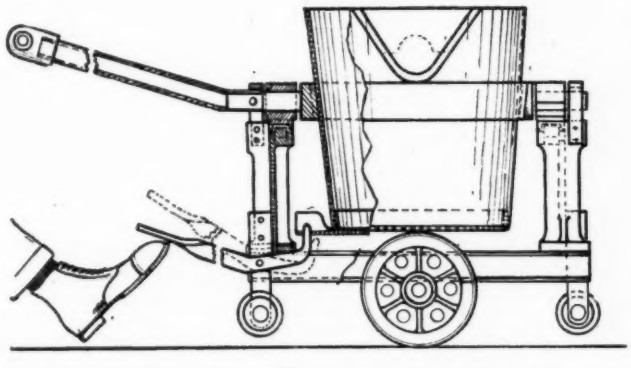
You will be glad to hear that your Gaiters proved their worth last week when some molten steel was splashed over the legs of a man who was wearing them. Had he been unprotected he must have been badly burned, but your Gaiters stopped the metal and he escaped uninjured. We have pleasure in sending you an order for a further dozen pairs.

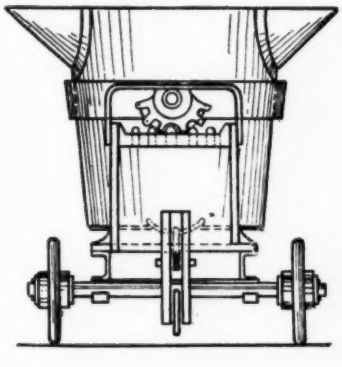
Yours faithfully,
(Signed) LAKE & ELLIOT, LIMITED.

Write for particulars of ASBESTOS PROTECTIVE GARMENTS, SAFETY GOGGLES, WELDERS' MASKS, SAND BLAST HELMETS, &c.

H. G. SOMMERFIELD, Charterhouse Chambers, London, E.C.1

I am a "Collin Ladle" and can stand alone.
I require no propping up, a boy can push me and use me.
I do not need a rail track to run on.
I skim myself with my specially arranged spout.
I am everything desirable and cheap.
Try me and you will find all my claims true.





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15, VICTORIA STREET, WESTMINSTER, S.W.1

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash ..	58	17	6
Three months ..	59	15	0
Electrolytic	66	10	0
Tough	63	15	0
Best selected ..	64	5	0
Sheets	90	0	0
India	73	0	0
Wire bars	66	10	0
Do. October ..	66	0	0
Do. November ..	66	0	0
Ingot bars	66	0	0
H.C. wire rods ..	69	15	0
Off. av. cash, Sept.	58	15	4 1/16
Do., 3 mths. Sept.	59	10	4 1/16
Do., Sttlmnt, Sept.	58	15	0
Do., Electro, Sept.	66	14	6 5/16
Do., B.S., Sept. ..	65	9	4½
Aver. spot price copper, Sept. ..	58	15	0
Do., wire bars, Sept.	66	18	6½
Solid drawn tubes			13d.
Brazed tubes ..			13d.
Wire			9½d.

BRASS.

Solid drawn tubes ..	12d.
Brazed tubes	13½d.
Rods, drawn	11½d.
Rods, extd. or rlld. ..	7½d.
Sheets to 10 w.g ..	10½d.
Wire	10½d.
Rolled metal	9½d.
Yellow metal rods ..	7½d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets ..	8½d.

TIN.

	£	s.	d.
Standard cash ..	312	5	0
Three months ..	301	15	0
English	310	10	0
Bars	312	5	0
Straits	319	10	0
Australian		—	
Eastern	315	0	0
Banca		—	
Off. avr. cash, Sept.	306	8	9
Do., 3 mths. Sept.	298	5	7½
Do., Sttlmt. Sept.	306	7	0 5/16
Aver. spot., Sept.	306	8	9

SPELTER.

Ordinary	34	3	9
Remelted	32	15	0
Hard	27	10	0
Electro 99.9 ..	36	10	0
English	34	15	0
India	30	0	0
Zinc dust	43	0	0
Zinc ashes	16	0	0
Off. aver., Sept. ..	34	8	0 11/16
Aver., spot, Sept.	34	7	9½

LEAD.

Soft foreign ppt.	30	15	0
English	32	0	0
Off. average, Sept.	31	18	9
Average spot, Sept.	32	1	8 5/16

ZINC SHEETS, &c.

Zinc sheets, English	42	15	0
Do. V.M. ex whf.	39	15	0
Rods	45	0	0
Boiler plates ..	39	0	0
Battery plates ..	38	10	0

ANTIMONY.

Special brands, Eng.	74	10	0
Chinese	62	10	0
Crude	42	0	0

QUICKSILVER.

Quicksilver ..	16	5	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon	
25%	9 2 6
45/50%	10 5 0
75%	16 0 0
Ferro-vanadium—	
35/40% 14/6 to 14/9 lb. va.	
Ferro-molybdenum—	
70/75% c. free ..	5/3 lb.
Ferro-titanium—	
23/25 % carbonless	11½d.
Ferro-phosphorus, 20/25%,	£17 0 0
Ferro-tungsten—	
80/85%, c.fr. ..	1/4½ lb.
Tungsten metal powder—	
98/99%	1/9 to 1/10 lb.
Ferro-chrome—	
2/4% car. ..	£33 0 0
4/6% car. ..	£23 0 0
6/8% car. ..	£21 15 0
8/10% car. ..	£20 15 0
Ferro-chrome—	
Max. 2% car.	£37 0 0
Max. 1% car.	£43 5 0
Max. 0.70% car.	£54 0 0
70%, carbonless	1/5 lb.
Nickel—99%,	
cubes or pellets ..	£170
Cobalt metal—98/99%	10/- lb.
Aluminium 98/99%	£107 to £112
Metallic Chromium—	
96/98% ..	3/- lb.
Ferro-manganese (net)—	
76/80%, loose	£14 0 0
76/80%, packed	£15 0 0
76/80%, export	£14 0 0
Metallic manganese—	
94/96%, carbonless	2/- lb.
Per ton unless otherwise stated.	

HIGH-SPEED TOOL STEEL.

	s.	d.
Finished bars, 14% tungsten ..	2	6
Finished bars, 18% tungsten ..	3	0

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares 3 in. and over .. 4d. lb.

Rounds and squares under ½ in. to ¼ in. 3d. lb.

Do. under ¼in. to 1/8 in. .. .. 1/- lb.

Flats, ½in. × ½in. to under 1 in. × ½ in. 3d. lb.

Do. under ½in. × ½in. 1/- lb

Bevels of approved sizes and sections 6d. lb.

Bars cut to length 10% extra

Scrap from high-speed tool steel—

Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Hvy. steel	2	12	6 to	2	17	6
Bundled steel & shrngs.	2	7	6 to	2	10	0
Mixed iron & steel	2	5	0 to	2	10	0
Heavy cast iron	2	15	0 to	3	0	0
Good machinery for foundries	2	17	6 to	3	5	0
Cleveland—						
Heavy steel ..		3	0		0	0
Steel turnings ..		2	7		6	
Cast iron borings		2	5		0	
Heavy forge ..		4	2		6	
Bushelled scrap		3	10		0	
Cast-iron scrap	3	8	0 to	3	10	0
Lancashire—						
Cast-iron scrap	3	2	6 to	3	10	0
Hvy. wrought ..		3	2		6	
Steel turnings ..		2	2		0	

London — Merchants' buying prices delivered yard.

Copper (clean) ..	49	0	0
Brass (clean) ..	38	0	0
Lead (less usual draft)	27	10	0
Tea lead ..	23	0	0
Zinc	23	0	0
New aluminium cuttings ..	82	0	0
Braziery copper	45	0	0
Gunmetal ..	46	0	0
Hollow pewter	200	0	0
Shaped black pewter ..	150	0	0

PIG-IRON.

(*f.o.t. unless otherwise stated*).

N.E. Coast—	
Foundry No. 1 ..	120/-
Foundry No. 3 ..	117/6
Foundry No. 4 ..	116 6
Forge No. 4	116/-
Hematite No. 1 ..	88/-
Hematite M/Nos. ..	87/6
N.W. Coast—	
Hem. M/Nos. d/d Glas.	88/6
„ d/d Birm	107/6 to 110/-
Midlands—	
Staffs common* ..	—
„ No. 4 forge ..	—
„ No. 3 foundry	—
Shrops. basic	—
„ Cold blast, ord.*	—
„ „ roll iron* ..	—
* d/d Birmingham.	
Northants forge	—
„ fdry No. 3 ..	—
Derbyshire forge	—
„ fdry. No. 3 ..	—
„ basic	—
Scotland—	
Foundry No. 1 ..	—
„ No. 3	97/6 to 100/-
Hem. M/Nos. ..	92/6
Sheffield (d/d district)—	
Derby forge	—
„ fdry. No. 3 ..	—
Lincs. forge	—
„ fdry. No. 3 ..	—
E.C. hematite	—
W.C. hematite ..	95/-
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3	—
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	—
„ fdry. No. 2 ..	—
Northants foundry No. 3	—
Dalzell, No. 3	117/6
Summerlee, No. 3 ..	117/6
Glengarnock, No. 3 ..	117/6
Gartsherrie, No. 3 ..	117/6
Monkland No. 3	117/6
Coltness, No. 3	117/6
Shotts, No. 3	117/6

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.) nom. ..	12	0	0 to	13	10	0
Angles		12	0		0	0
Tees to 3 united ins.		12	10		0	
Nut and bolt iron		—				
Hoops		14	10		0	
Marked bars (Staffs.) f.o.t. ..		14	0		0	
Gas strip		12	10		0	
Bolts and nuts .. ¾ in. × 4 in. ..		15	5		0	
Steel—						
Ship plates		8	12		6	
Boiler plts. ..		11	5		0	
Chequer plts. ..		9	10		0	
Angles		7	12		6	
Tees		8	12		6	
Joists		7	12		6	
Rounds and Squares 3 in. to 5½ ins. ..		9	0		0	
Rounds under 3 in. to ¾ in.		8	12		6	
Flats, over 5 in. wide and up ..		9	10		0	
Flats, 5in. to 1½in.		8	10		0	
Rails, heavy ..		8	10		0	
Fishplates		12	10		0	
Hoops (Staffs.) ..		10	10		0	
Black sheets, 24g.		11	7		6	
Galv. cor. sheets, 24g.	16	10	0 to	16	15	0
Galv. fencing wire 8g. plain		12	10		0	
Billets, soft ..		7	15		0	
Billets, hard ..		8	2		6	
Sheet bars	7	0	0 to	7	10	0
Tin bars d/d	7	0	0 to	7	10	0

PHOSPHOR BRONZE.

	Per lb.	basis.
Strip	1	3
Sheet to w.g.	1	3½
Wire	1	4
Rods	1	3
Tubes	1	8
Castings	1	2

Delivery 3 cwt. free

10% phos. cop. £40 above B.S.

15% phos. cop. £50 above B.S.

Phosphor tin (5%) £30 above price of English ingots.

C. Clifford & Son, Limited.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks ..	9d. to 1/5½
Ingots rolled to spoon size ..	1/- to 1/8½
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	21.76
No. 2 foundry, Valley	19.76
No. 2 foundry, Birm.	20.00
Basic	19.26
Bessemer	20.26
Malleable	19.76
Grey forge	19.26
Ferro-mang. 80% d/d	88.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	35.00
O.-h. billets	35.00
O.-h. sheet bars ..	36.00
Wire rods	45.00
	Cents.
Iron bars, Phila. ..	2.22
Steel bars	2.00
Tank plates	1.90
Beams, etc.	2.00
Skelp, grooved steel ..	1.90
Skelp, sheared steel ..	1.90
Steel hoops	2.50
Sheets, black, No. 24 ..	3.00
Sheets, galv., No. 24 ..	3.85
Sheets, blue an'l'd, 9 & 10	2.30
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv. ..	3.35
Tinplate, 100 lb. box	$5.50

COKE (at ovens).

Welsh foundry	—
„ furnace	—
Durham & North.	
„ foundry	—
„ furnace	57/6
Other Districts, foundry	—
„ „ furnace (basis)	—

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes,	20×14, box	22/3
„	28×20, „	44/6
„	20×10, „	—
„	18¾×14, „	—
C.W.	20×14, „	—
„	28×20, „	—
„	20×10, „	—
„	18¾×14, „	—

Terneplates 28×20, — per box basis f.o.b.

SWEDISH IRON.

Bars, hammered	£18/10 to £19/0
Rolled Ord.	£15/10/0 to £16
Nail rods	£16 5 0 to £16 15 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£9 to £12
Pig-iron	£6 0 0 to £6 10 0

all f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes	*Fittings*
Gas	60%	50%
Water	55%	45%
Steam	50%	40%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (Cash).

		£	s.	d.		
Oct.	7	57	10	0	dec.	5/–
,,	8	57	7	6	,,	2/6
,,	11	57	12	6	inc.	5/–
,,	12	58	0	0	,,	7/6
,,	13	58	17	6	,,	17/6

Electrolytic Copper.

		£	s.	d.		
Oct.	7	65	15	0	dec.	5/–
,,	8	65	15	0	No change	
,,	11	65	15	0	,, ,,	
,,	12	66	0	0	inc.	5/–
,,	13	66	10	0	,,	10/–

Standard Tin (Cash).

		£	s.	d.		
Oct.	7	318	10	0	inc.	10/–
,,	8	315	5	0	dec.	65/–
,,	11	315	0	0	,,	5/–
,,	12	312	5	0	,,	55/–
,,	13	312	5	0	No change	

Tin (English ingots).

		£	s.	d.		
Oct.	7	316	5	0	dec.	5/–
,,	8	313	5	0	,,	60/–
,,	11	313	0	0	,,	5/–
,,	12	310	5	0	,,	55/–
,,	13	310	10	0	inc.	5/–

Zinc Sheets (English).

		£	s.	d.		
Oct.	7	42	15	0	No change	
,,	8	42	15	0	,, ,,	
,,	11	42	15	0	,, ,,	
,,	12	42	15	0	,, ,,	
,,	13	42	15	0	,, ,,	

Spelter (ordinary).

		£	s.	d.		
Oct.	7	34	0	0	dec.	7/6
,,	8	33	18	9	,,	1/3
,,	11	34	3	9	inc.	5/–
,,	12	34	2	6	dec.	1/3
,,	13	34	3	9	inc.	1/3

Lead (English).

		£	s.	d.		
Oct.	7	32	5	0	No change	
,,	8	31	15	0	dec.	10/–
,,	11	31	15	0	No change	
,,	12	31	15	0	,, ,,	
,,	13	32	0	0	inc.	5/–

AVERAGE PRICES OF GALVANISED CORRUGATED SHEETS (NORTH OF ENGLAND).

	Jan.			Feb.			March			April			May			June			July			Aug.			Sept.			Oct.			Nov.*			Dec.			Yearly average		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
1901	13	0	0	12	5	0	11	10	0	11	16	0	11	10	0	11	10	0	11	10	0	11	10	0	12	0	0	12	0	0	12	0	0	12	0	0	11	17	1
1902	12	0	0	11	10	0	11	10	0	11	10	0	11	15	0	11	15	0	11	15	0	11	15	0	11	15	0	11	15	0	11	15	0	11	15	0	11	14	2
1903	11	5	0	11	5	0	11	5	0	11	10	0	11	10	0	11	10	0	11	10	0	11	10	0	11	5	0	11	5	0	11	5	0	11	5	0	11	7	1
1904	11	5	0	11	5	0	11	5	0	11	5	0	10	15	0	10	15	0	10	15	0	10	15	0	10	5	0	10	5	0	10	5	0	10	5	0	10	15	0
1905	10	7	6	10	7	6	10	7	6	10	7	6	10	7	6	10	7	6	10	7	6	10	7	6	11	0	0	11	5	0	11	15	0	12	0	0	10	15	0
1906	12	12	6	12	12	6	12	12	6	12	7	6	12	7	6	12	7	6	12	12	6	12	12	6	12	15	0	12	15	0	12	15	0	13	5	0	12	12	11¼
1907	13	5	0	13	5	0	13	15	0	13	15	0	13	15	0	13	15	0	13	17	6	13	17	6	13	17	6	13	2	6	13	2	6	13	2	6	13	10	10
1908	13	2	6	12	10	0	12	10	0	12	10	0	12	10	0	12	10	0	12	10	0	12	10	0	12	10	0	12	10	0	12	10	0	12	10	0	12	11	0½
1909	12	10	0	12	10	0	12	10	0	12	10	0	12	10	0	12	10	0	12	10	0	12	10	0	11	0	0	11	0	0	11	0	0	11	0	0	11	16	8
1910	11	15	0	12	5	0	12	5	0	11	15	0	11	10	0	11	10	0	11	12	6	11	12	6	11	12	6	11	12	6	11	10	0	11	10	0	11	13	4
1911	11	5	0	11	1	3	10	15	0	10	15	0	10	13	9	10	10	0	10	13	9	11	0	0	11	5	0	11	5	0	11	5	0	11	7	0	10	19	7½
1912	11	10	0	11	10	0	11	10	0	11	15	0	12	5	0	12	5	0	12	5	0	12	5	0	12	5	0	12	5	0	12	12	6	12	18	0	12	15	0	12	2	11½
1913	12	15	0	12	15	0	12	15	0	12	11	3	11	18	0	11	15	0	11	15	0	11	15	0	11	15	0	11	15	0	11	3	0	11	0	0	11	2	6	11	18	4
1914	11	7	0	11	7	6	11	7	6	11	5	7½	11	2	6	10	15	0	10	15	0	12	17	6	14	2	0	13	7	0	11	15	7	11	2	6	11	16	0
1915	11	10	8½	13	12	6	14	8	9	15	0	6	17	17	6	20	17	6	20	17	6	20	6	3	17	12	6	18	1	0	22	13	0	25	2	0	18	3	4½
1916	26	5	0	27	12	6	28	0	0	28	5	0	29	0	0	29	0	0	28	15	0	28	3	0	28	15	0	28	15	0	28	15	0	28	15	0	28	6	8½
1917	28	15	0	28	15	0	28	15	0	28	15	0	28	15	0	28	15	0	28	15	0	28	15	0	28	15	0	28	0	0	28	0	0	28	0	0	28	11	3
1918	28	5	0	28	15	0	29	0	0	29	0	0	29	0	0	29	0	0	29	0	0	29	0	0	29	0	0	29	0	0	29	0	0	29	0	0	28	13	4
1919	29	0	0	29	0	0	29	0	0	28	0	0	28	10	0	27	7	6	27	5	0	29	3	0	32	0	0	33	0	0	36	10	0	40	8	4	31	5	3½
1920	46	10	0	49	15	0	53	15	0	56	0	0	55	10	0	54	10	0	52	10	0	48	10	0	44	3	4	39	2	6	35	17	6	30	8	0	47	4	3
1921	28	10	0	25	17	6	24	5	0	23	3	4	22	0	0	22	0	0	23	10	0	21	12	6	20	0	0	18	15	0	18	3	9	17	2	0	22	1	7
1922	16	17	6	15	13	9	16	3	0	16	10	0	16	4	4½	15	15	6	15	16	3	16	16	0	16	8	9	16	6	3	17	1	0	17	7	6	16	7	5½
1923	18	3	1½	19	1	11½	19	8	0	19	10	0	19	7	0	19	1	3	18	0	0	18	13	1½	19	0	0	19	3	9	19	2	6	18	19	4½	18	19	2
1924	18	13	6	18	9	4½	18	5	0	17	15	11½	17	3	0	17	19	4½	18	7	6	18	8	1½	18	8	1½	17	19	6	17	11	3	17	10	0	18	0	10½
1925	17	8	6	17	1	6½	16	9	4½	16	12	0	16	9	8½	16	9	4½	16	0	6	16	1	10½	16	5	0	16	7	0	16	12	6	16	15	0	16	11	0½
1926	16	14	4½	16	5	7½	16	0	6	15	11	10½	15	11	3	16	0	0	16	16	0	16	18	9	16	14	4½		—			—			—			—		

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FOUNDRY SUPT. AND MOULDING MACHINE PRODUCTION EXPERT desires position; able to get excellent results from machines considered failures; trained Metallurgist; keen and energetic organiser.—Box 814, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

FOREMAN or Assistant Patternmaker, wood and metal, desires change; 9 years' Assistant, 12 years' experience of Aircraft Engine patterns; specialised in air- and water-cooled aluminium cylinders, good practical foundry knowledge, conversant with all up-to-date methods of plate and machine moulding; capable of handling men; good references.—Apply, Box 834, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

REPRESENTATIVE, technical, 15 years' experience Foundry work, live connection Foundries Scotland and North of England, seeks new engagement as Representative for Foundry Plant and Requisites.—Apply Box 825, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

CHEMIST AND METALLURGIST, specialising in Foundry practice, Cupola control and production of Refined Iron for market, also expert in mass production, lay-outs, Machine Moulding, etc., shortly open for new appointment.—Apply Box 828, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

WANTED, Assistant Foreman Moulder with extensive experience in high-class General Engineering work, up to 40 tons in weight; must have expert practical knowledge of Moulds and Furnace work; competent to read drawings and fix piecework prices; a good opportunity for a keen and energetic man; all correspondence will be treated strictly confidential.—Write, in first instance, giving full details of experience, firms worked for, age and salary required, to Box 830, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

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AGENCIES.

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WANTED, an Engineering Firm using a fair amount of Iron Castings, to take an interest in an Iron Foundry casting from 30 cwts. to 2 tons daily.—Apply, Box 832, Offices of The Foundry Trade Journal, 49, Wellington Street, Strand, London, W.C.2.

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PATENTS.

THE OWNERS of British Patent No. 216580 entitled "An Improved Process for Extracting Tin from Its Ores," No. 220012 entitled "Process of Electrolytically Refining Tin Bullion," No. 219719 entitled "Process of Producing Metallic Tin," and No. 176080 entitled "Improvements in Power Driven Load Carrying Trucks," desire to dispose of the same or would grant a licence to work the Inventions on royalty terms.—Particulars may be obtained from Technical Records, Ltd., of 59-60, Lincoln's Inn Fields, London, W.C.2.

IT IS DESIRED to secure the full commercial development in the United Kingdom of British Patent No. 206120, which relates to Sealing the Jointed Surfaces of Sand and like Moulds, either by way of sale or the grant of licences on reasonable terms.—For particulars, apply Phillips, 70, Chancery Lane, London, W.C.2.

THE PROPRIETOR of the Patent No. 210118*, for Improved Manufacture of Grey Iron, is desirous of entering into arrangements by way of licence and otherwise on reasonable terms for the purpose of exploiting the same and ensuring its full development and practical working in this country.—All communications should be addressed in the first instance to Haseltine, Lake & Co., Chartered Patent Agents, 28, Southampton Buildings, Chancery Lane, London, W.C.2.

MISCELLANEOUS.

PATTERNS.—Inquiries solicited; quotations by return; shop equipped with modern machinery; quick delivery.—Cleghorn & Company, Midland Pattern Works, Spring Gardens, Worcester. Phone 264.

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NEW 2 ton, by Thwaites	£25
NEW 2½ ton, by Geo. Green	£30
3½ ton, by Stevensons	£30
5 ton, by James Evans & Co.	£45
12 ton, by James Evans & Co.	£75

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